BMJ Open

Multimorbidity in a marginalised, street-health Australian population: A retrospective cohort study

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2014-005461
Article Type:	Research
Date Submitted by the Author:	14-Apr-2014
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Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	General practice / Family practice
Keywords:	PRIMARY CARE, multimorbidity, chronic disease

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Word count (excluding title page, abstract, references, figures and tables): **3,484**

ABSTRACT

Objectives: To examine the demographic and presentation profile of patients using an innovative mobile outreach clinic and compare this service with patients attending mainstream practice.

Design: Retrospective cohort study.

Setting: Two primary care clinics in Western Australia: mobile street health clinic and mainstream practice.

Participants: 2587 street health patients and 4583 mainstream patients.

Main outcome measures: Prevalence and patterns of chronic diseases in anatomical domains across entire age spectrum of patients and disease severity burden using Cumulative Illness Rating Scale (CIRS).

Results: Multimorbidity (2+ CIRS domains) was lower in the street health (46.4%, 1199/2587) than mainstream sample (50.1%, 2294/4583), p=0.003 but street health patients showed significantly greater disease severity. Controlling for age and gender, mean CIRS Severity Index score for street health (M = 1.4, SD = 0.91) was significantly higher than mainstream patients (M = 1.1, SD = 0.80), p<0 .001. Furthermore, 44.2% (530/1199) of street health patients had at least one level 3 or 4 score across domains compared to 18.3% (420/2294) of mainstream patients, p<0.001.

Younger street health patients (14-43 years) showed greater multimorbidity than mainstream patients. Prevalence is significantly lower in street health (62.3%, 584/938) if aged 45+ years compared to mainstream patients (78.7%, 1277/1622), p<0.001.

Aboriginal patients were 29.6% (766/2587) of street health population with 50.4% (386/766) having multimorbidity compared with 44.6% (813/1821) for non-Aboriginals, p=0.007. Musculoskeletal, respiratory and psychiatric domains were most commonly affected with multimorbidity significantly associated with male gender, increasing age and Indigenous status.

Conclusions: Multimorbidity prevalence is lower in street health cohort but with greater severity. Early onset (23-34 years old) multimorbidity is higher in street health cohort but prevalence is lower in 45+ years than mainstream patients. Multimorbidity prevalence is higher for Aboriginal patients of all ages.

ARTICLE SUMMARY

Strengths and limitations of the study

- New information on a vulnerable, street-based population accessing an accredited, mobile outreach medical service.
- The large cohort size (n=2587) involving a total street based population seen over a six year period compared with 4583 mainstream patients from similar catchment area.
- Includes a severity rating for each patient in addition to prevalence and patterns of chronic diseases recorded.
- The open access policy to the street health service could have diluted the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances.
- The street health population is based on data collected over a six year period while the comparator mainstream practice data was collected over six months.

KEY WORDS

Multimorbidity, chronic disease, primary healthcare, general practice, severity of illness index

INTRODUCTION

The combination of multiple chronic diseases (multimorbidity) and poor access to primary health care results in serious social, economic and health consequences[1-5] as well as providing considerable challenges for service providers. Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect healthcare costs[6,7] and poor utilisation of primary care health services.[1,8-11] Alcohol and drug related deaths, smoking related diseases, ischemic heart disease and respiratory diseases are especially common.[9] A systematic review[12] found homeless people in Western countries had much greater drug and alcohol dependence compared to age-matched populations while psychotic illnesses and personality disorders were also more common. Canadian homeless and marginally housed people have 32% probability of survival to 75 years among men and 60% among women with housing a key marker for socioeconomic disadvantage.[9] Death rates among 'rough sleepers' in the United Kingdom are 25 times that of the housed population.[13]

Risk factors influencing access to health services include lack of suitable housing,[9,14] mental health problems,[12,15] poor education, unemployment and lack of regular income.[16,17] Social marginalisation impacts negatively on healthcare utilisation including fear of stigmatisation on visiting mainstream practices and waiting rooms.[18] People from Indigenous, non-English speaking and refugee backgrounds often avoid contact with a regular doctor and only seek help when a crisis develops.[19-21] Such individuals have poorer health outcomes[22] exhibiting patterns of chronic, multimorbid disease at a younger age compared to the general population.[23] In Scotland, Mercer[3] found an increased burden of ill-health and multimorbidity in deprived areas resulting in greater demands on primary health care leading to reduced access, less patient-doctor time and more GP stress but less patient enablement.

The "Freo Street Doctor", an accredited, street-based mobile health clinic established in 2005 to help meet the needs of marginalised and homeless patients unable or unwilling to access mainstream primary health care, operates in a number of designated areas within Fremantle and surrounding suburbs in Western Australia. The clinic team consists of general practitioners, nurses, outreach workers, Indigenous health workers and social workers. Our study aims to examine the demographic profile of patients using this street health service compared to mainstream primary care practices, the range and severity of morbidities/chronic diseases across anatomical domains and compares these parameters for Aboriginal and non-Aboriginal patients.

METHOD

Study Setting

The entire patient cohort attending the "Freo Street Doctor" service over the period 1 January 2006 to 31 December 2011 was examined using data extracted from electronic medical records stored at the Fremantle Medicare Local. Data from the street health patient cohort were compared with a subset of patient data from a mainstream general practice clinic[24] servicing the same catchment area over the period 1 July to 31 December 2008.

Data Extraction

Data extraction was undertaken by two GPs and two medical students, all with similar training and prior experience in the use and application of the Cumulative Illness Rating Scale (CIRS). The scoring of chronic conditions using the validated CIRS has been described in detail previously[20,25] as has the Severity Index (SI) classification.[24]

The street health dataset contained a large number of one-off consultations. Some attendees had no fixed abode with many using drop-in centres as proxy addresses. Because the study population was considered at higher risk than same age patients attending mainstream practices and clinical information was limited in some instances, we included patients with conditions that appeared to be ongoing (for example, skin infections post lacerations or scabies infestation). We did so to reflect the types of problems presenting to the Street health service and the fact that such conditions were often of much greater magnitude in disadvantaged, marginalised populations such as the homeless and drug users.

Operational Definition

Our operational definition of multimorbidity was the co-occurrence of conditions across two or more (2+) domains in individual patients.[26] After data extraction was completed, a random sample of 30 patients across the entire age spectrum for both clinics was re-assessed to measure consistency among raters.

Data Analysis

Data analysis was conducted using SPSS 22 (IBM Corporation). All statistical analyses were tested against an alpha level of 0.05 (two-tailed).

Sample characteristics are expressed as means (standard deviation of the mean) for continuous variables and as frequencies (percentages) for categorical variables. Independent samples t-tests and Chi-Square tests were used to examine any demographic differences between the two samples.

The prevalence of multimorbidity was calculated as the number of patients with long-term conditions in 2+ morbidity domains as a proportion of the total sample. Chi-square tests were used to examine prevalence differences between the two cohorts. Patterns of multimorbidity are expressed as frequencies.

To examine age of onset of multimorbidity, we modelled the probability of multimorbidity as a function of age. First, a logistic regression analysis was run with the presence of multimorbidity as the dependent variable, and clinic, age, and age squared (given the non-linear relationship between age and multimorbidity) as independent variables (IV). The regression coefficients (β) for each IV were then used to model the probability of multimorbidity as a function of age in each sample.

Multimorbidity severity was examined using the CIRS SI score as well as distribution of patients within each CIRS severity category. SI categories were defined as 0 (none), 1 (mild), 2 (moderate) and 3 or 4 (severe). General linear modelling (GLM) was used to examine differences in multimorbidity severity between the two samples, controlling for age and gender. We also counted and compared the number of patients with at least one level 3 or 4 score across CIRS domains,[20] as well as the number of domains with a level 3 or 4 score for each patient as additional indicators of disease severity.

Subgroup analysis was conducted to examine the prevalence and severity of multimorbidity in Indigenous and non-Indigenous patients in the street health cohort. There was no data on Indigenous status in the mainstream cohort for comparison.

We also examined the relationship between demographic characteristics and the presence of multimorbidity across 2, 3, and 5 domains using a series of logistic regression analyses.

Inter-rater reliability between data extractors was assessed using Cronbach's alpha.

Ethics

Ethics approval for the study was obtained from The University of Notre Dame Australia Human Research Ethics Committee.

RESULTS

Patient Characteristics

A total of 2587 patients attended the street health service and 4583 attended mainstream practice over the study periods. The age and gender distribution of patients at both clinics are shown in Table 1. The mean age of street health patients was 37.8 years (SD = 18.7) compared with 36.2 (SD = 21.1) for the mainstream practice. There were no significant differences in age between the two cohorts, p=0.055, but a significant difference in gender distribution was observed. The majority of the street health patients were male (57.3%, 1482/2587) while the majority of patients attending mainstream practice were female (60.7%, 2783/4583), p<0.001.

Table 1. Age and Gender Distribution for Study Population

	Fremantle Street Doctor			Mainstream practice (n = 4583)
	Overall (n = 2587)	Aboriginal (n = 766)	Non-Aboriginal (n = 1821)	
Sex, % (n)				
Male	57.3 (1482)	50.3 (385)	60.2 (1097)	39.3 (1800)
Female	42.7 (1105)	49.7 (381)	39.8 (724)	60.7 (2783)
Age, mean (SD) [range]				
Overall	37.8 (18.7) [0 to 103]	32.09 (17.9) [0 to 81]	40.19 (18.5) [0 to 103]	36.18 (21.1) [0 to 98]
Male	39.1 (18.5) [0 to 103]	31.8 (18.1) [1 to 81]	41.6 (17.9) [0 to 103]	35.1 (22.3) [0 to 92]
Female	36.1 (18.7) [0 to 90]	32.3 (17.7) [0 to 75]	38.0 (18.9) [0 to 90]	36.9 (20.3) [0 to 98]
Age Category, % (n)				
< 25	24.2 (626)	36.8 (282)	18.9 (344)	28.9 (1326)
25 to 44	39.5 (1023)	35.8 (274)	41.1 (749)	35.7 (1635)
45 to 64	28.3 (732)	24.4 (187)	29.9 (545)	27.1 (1243)
65 to 74	5.3 (136)	2.3 (18)	6.5 (118)	4.6 (211)
75+	2.7 (70)	0.7 (5)	3.6 (65)	3.7 (168)

Aboriginal patients were 29.6% (766/2587) of the street health sample. On average, Aboriginal patients were significantly younger than non-Aboriginal patients, with 36.8% (282/766) under the age of 25 compared with only 18.9% (344/1821) of non-Aboriginals, p<0.001. The majority of non-Aboriginal patients were male (60.2%, 1097/1821) while there was a more even gender distribution for Aboriginal patients attending the street health service (male 50.3%, 385/766), p<0.001.

Inter-rater Reliability

Inter-rater reliability between data extractors was tested on CIRS scores and number of domains with morbidities for 30 randomly selected patients from each of the two cohorts. For the street health cohort, the intraclass correlation coefficient (ICC) was 0.94 (95% confidence interval 0.89 to 0.97) for number of domains with morbidities and 0.96 (95% CI 0.93 to 0.98) for total CIRS scores

indicating high inter-rater reliability. For the mainstream practice sample, the ICC was 0.98 (95% CI 0.97 to 0.99) for number of domains with morbidities and 0.98 (95% CI 0.97 to 0.99) for CIRS scores.

Prevalence of Multimorbidity

Overall, the prevalence of multimorbidity was lower in the street health sample. Multimorbidity, based on the presence of conditions affecting 2+ domains, was present in 46.3% (1199/2587, 95% confidence interval 44.4 to 48.3%) of street health patients, compared with 50.1% (2294/4583, 95% CI 48.6 to 51.5%) of the mainstream sample, p=0.003. A total of 28.0% (724/2587) of the street health cohort had multimorbidity in 3+ domains compared with 31.9% (1464/4583) of mainstream patients, p<0.001. Across 5+ domains, 10% (259/2587) of street health patients showed multimorbidity compared with 12.8% (587/4583) of the mainstream sample, p<0.001.

Figure 1 shows the prevalence of multimorbidity across 2+ domains for both samples across age groups. The prevalence of multimorbidity among young street health patients aged < 45 years (37.7%, 615/1649) was significantly higher than in the mainstream sample (34.3%, 1017/2961), p=0.045. However, multimorbidity prevalence was significantly lower in the street health sample for patients 45+ years (62.3% [584/938] vs 78.7% [1277/1622], respectively), p<0.001.

Age of onset of multimorbidity was different for the two populations (Figure 2). For street health patients, the probability of multimorbidity peaked between 61 and 67 years, P ($E_{\text{STREET HEALTH}}$)= 0.78, and then decreased. For mainstream patients, the probability of multimorbidity increased with age, with the greatest probability of multimorbidity observed for individuals aged over 70 years, P ($E_{MAINSTREAM}$)= 0.99. Between the ages of 14 and 43, the probability of multimorbidity was higher for street health patients, P ($E_{\text{STREET HEALTH}}$) = 0.26 to 0.71 vs. P ($E_{\text{MAINSTREAM}}$) = 0.24 to 0.69, suggesting that younger street health patients are particularly vulnerable to multimorbidity. The greatest difference was observed between the ages of 23 and 34, P ($E_{\text{STREET HEALTH}}$) = 0.43 to 0.62 vs. P ($E_{\text{MAINSTREAM}}$) = 0.33 to 0.52, with street health patients showing a mean 12% greater chance of multimorbidity than mainstream patients in this age group.

Overall for the street health Aboriginal patients, multimorbidity (2+ domains) was present in 50.4% (386/765, 95% confidence interval 46.9 to 53.9%) compared with 44.6% (813/1821, 95% CI 42.4 to 46.9%) in non-Aboriginals, $p=0.0$07. A total of 33.2% of Aboriginal patients (254/766) had 3+ domains affected compared with 25.8% (470/1821) in non-Aboriginals, p<0.001, while 13.7% (105/765) had 5+ domains affected compared with 8.5% (154/1821) in non-Aboriginals, p<0.001. Stratified by age, the prevalence of multimorbidity (2+) across all age groups was significantly higher among Aboriginal compared with non-Aboriginal patients, p<0.001 (Figure 3).

Patterns of Multimorbidity

Table 2 displays the prevalence of the five most common body system domain combinations across single, 1+, 2+, 3+ and 5+ domains for the street health sample with corresponding prevalence rates in mainstream practice for comparison. Table 2 also displays the prevalence of the five most common domain combinations stratified by age.

Table 3 displays the prevalence of the five most common domain combinations across single, 1+, 2+, 3+ and 5+ domains stratified by Indigenous status and age.

Table 2. Overall and age category breakdown for the 5 most common domains for Street Health cohort

	Domains	Street Health % (*n*)	Mainstream practice % (*n*)[a-d]	Age category (Street health cohort only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 798)	Musculoskeletal	29.8 (238)**	21.8 (231)	24.2 (58)	49.2 (117)	19.7 (47)	5.9 (14)	0.8 (2)
	Psychiatric	20.3 (162)	18.7 (198)	20.4 (33)	53.7 (87)	24.1 (39)	1.9 (3)	0
	Eye, ear, nose and throat	13.7 (109)*	9.7 (103)	62.4 (68)	18.3 (20)	14.7 (16)	0.9 (1)	3.7 (4)
	Respiratory	9.4 (75)	17.8 (188)	38.7 (29)	29.3 (22)	30.7 (23)	1.3 (1)	0
	Genitourinary	6.9 (55)	8.5 (90)	14.5 (8)	69.1 (38)	14.5 (8)	1.8 (1)	0
One or more domains (*n* = 1997)	Psychiatric	46.7 (933)**	34.6 (1161)	8.6 (80)	48.9 (456)	36.5 (341)	4.7 (44)	1.3 (12)
	Musculoskeletal	42.9 (856)	45.2 (1514)	13.1 (112)	44.6 (382)	31.8 (272)	7.1 (61)	3.4 (29)
	Respiratory	35.0 (699)	35.6 (1193)	11.7 (82)	43.2 (302)	38.6 (270)	4.9 (34)	1.6 (11)
	Eye, ear, nose and throat	19.1 (381)*	22.7 (762)	29.4 (112)	29.7 (113)	29.7 (113)	6.3 (24)	5.0 (19)
	Vascular	18.2 (364)**	22.3 (746)	3.3 (12)	17.6 (64)	53.8 (196)	13.5 (49)	11.8 (43)
Two or more domains (*n* = 1199)	Psychiatric + Respiratory	37.1 (445)**	18.8 (432)	7.2 (32)	48.3 (215)	39.1 (174)	4.3 (19)	1.1 (5)
	Psychiatric + Musculoskeletal	32.4 (388)**	22.2 (510)	3.6 (14)	47.2 (183)	41.8 (162)	5.7 (22)	1.8 (7)
	Respiratory + Musculoskeletal	25.6 (307)*	22.4 (515)	5.9 (18)	42.3 (130)	43.3 (133)	6.8 (21)	1.6 (5)
	Vascular + Musculoskeletal	14.6 (175)**	19.4 (445)	2.3 (4)	17.7 (31)	50.9 (89)	15.4 (27)	13.7 (24)
	Hepatic-Pancreatic + Psychiatric	14.3 (172)**	2.8 (64)	1.7 (3)	45.9 (79)	45.9 (79)	5.3 (9)	1.2 (2)
Three or more domains (*n* = 724)	Psychiatric + Respiratory + Musculoskeletal	30.9 (224)**	14.7 (215)	3.6 (8)	42.4 (95)	47.3 (106)	5.8 (13)	0.9 (2)
	Psychiatric + Haematological + Endocrine	14.5 (105)	14.1 (206)	3.8 (4)	37.1 (39)	46.7 (49)	8.6 (9)	3.8 (4)
	Psychiatric + Respiratory + Vascular	14.4 (104)**	8.5 (125)	2.9 (3)	25.0 (26)	60.6 (63)	8.7 (9)	2.9 (3)
	Psychiatric + Musculoskeletal + Vascular	14.2 (103)	13.1 (192)	1.0 (1)	18.4 (19)	60.2 (62)	14.6 (15)	5.8 (6)
	Psychiatric + Respiratory + Lower Gastrointestinal	13.8 (100)**	5.9 (87)	1.0 (1)	46.0 (46)	50.0 (50)	1.0 (1)	2.0 (2)

[a] For 1 domain only, denominator (n = 1058), [b] For 1+ domains, denominator (n = 3352), [c] For 2+ domains, denominator (n = 2294), [d] For 3+ domains, denominator (n = 1772)

* Chi square test significant at .05 level vs mainstream practice

** Chi square test significant at .001 level vs mainstream practice

Table 3. Overall and age category breakdown for the 5 most common domains for Aboriginal Street Health patients

	Domains	Aboriginal % (*n*)	Non-Aboriginal % (*n*) [a-d]	Age category (Aboriginal patients only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 216)	Musculoskeletal	34.3 (74)	28.2 (164)	55.4 (41)	36.5 (27)	8.1 (6)	0	0
	Eye, ear, nose and throat	19.0 (41)*	11.7 (68)	85.4 (35)	12.2 (5)	2.4 (1)	0	0
	Psychiatric	13.0 (28)*	23.0 (134)	25.0 (7)	57.1 (16)	17.9 (5)	0	0
	Respiratory	8.3 (18)	9.8 (57)	55.6 (10)	22.2 (4)	22.2 (4)	0	0
	Lower gastrointestinal	6.0 (13)	5.0 (29)	30.8 (4)	53.8 (7)	15.4 (2)	0	0
One or more domains (*n* = 602)	Musculoskeletal	47.5 (286)*	40.9 (570)	25.9 (74)	40.2 (115)	30.1 (86)	3.1 (9)	0.7 (2)
	Psychiatric	45.5 (274)	47.2 (659)	10.6 (29)	47.8 (131)	37.2 (102)	4.0 (11)	0.4 (1)
	Respiratory	38.7 (233)*	33.4 (466)	16.3 (38)	42.5 (99)	36.9 (86)	3.4 (8)	0.9 (2)
	Eye, ear, nose and throat	24.9 (150)**	16.6 (231)	42.0 (63)	27.3 (41)	24.7 (37)	4.0 (6)	2.0 (3)
	Endocrine	24.4 (147)**	13.3 (186)	7.5 (11)	34.0 (50)	46.9 (69)	8.8 (13)	2.7 (4)
Two or more domains (*n* = 386)	Psychiatric + Respiratory	39.6 (153)	35.9 (292)	9.8 (15)	47.7 (73)	38.6 (59)	3.3 (5)	0.7 (1)
	Psychiatric + Musculoskeletal	35.2 (136)	31.0 (252)	5.1 (7)	46.3 (63)	44.1 (60)	4.4 (6)	0
	Respiratory + Musculoskeletal	31.3 (121)*	22.9 (186)	9.1 (11)	42.1 (51)	43.8 (53)	4.1 (5)	0.8 (1)
	Respiratory + Endocrine	20.2 (78)**	7.7 (63)	5.1 (4)	35.9 (28)	50.0 (39)	7.7 (6)	1.3 (1)
	Psychiatric + Endocrine	19.2 (74)**	10.2 (83)	5.4 (4)	36.5 (27)	47.3 (35)	9.5 (7)	1.4 (1)
Three or more domains (*n* = 254)	Psychiatric + Respiratory + Musculoskeletal	35.8 (91)*	28.3 (133)	5.5 (5)	44.0 (40)	47.3 (43)	3.3 (3)	0
	Psychiatric + Haematological + Endocrine	22.4 (57)**	10.2 (48)	3.5 (2)	40.4 (23)	47.4 (27)	7.0 (4)	1.8 (1)
	Respiratory + Musculoskeletal + Endocrine	18.9 (48)**	7.4 (35)	2.1 (1)	31.3 (15)	60.4 (29)	6.3 (3)	0
	Vascular + Respiratory + Endocrine	18.5 (47)**	6.8 (32)	0	27.7 (13)	63.8 (30)	6.4 (3)	2.1 (1)
	Psychiatric + Vascular + Respiratory	18.1 (46)*	12.3 (58)	2.2 (1)	28.3 (13)	65.2 (30)	2.2 (1)	2.2 (1)

[a] For 1 domain only, denominator (n = 582), [b] For 1+ domains, denominator (n = 1395), [c] For 2+ domains, denominator (n = 813), [d] For 3+ domains, denominator (n = 470)

* Chi square test significant at .05 level vs Non-Aboriginal

** Chi square test significant at .001 level vs Non-Aboriginal

Multimorbidity Severity Index

Overall, GLM analysis revealed a significantly greater severity of disease among the street health cohort. Controlling for age and gender, street health patients (M = 1.4, SD = .91) had significantly higher multimorbidity severity than mainstream patients (M = 1.1, SD = .80), $p<0.001$.

A significantly greater proportion of the street health patients were represented in the moderate (34.1%, 883/2587, 95% confidence interval 32.3 to 35.9%), $p<0.001$, and severe categories (4.9%, 126/2587, 95% CI 4.1 to 5.8%), $p<0.001$, compared with mainstream patients (moderate: 21.0%, 961/4583, 95% CI 19.8 to 22.2%; severe: 1.2%, 53/4583, 95% CI, 0.9 to 1.5%). When multimorbidity severity was stratified by age (Figure 4), a greater proportion of street health patients were again represented in the moderate and severe categories across every age category.

Overall, 24.4% (632/2587) of street health patients compared to 10.1% (463/4583) of mainstream patients had at least one level 3 or level 4 score across domains, $p<0.001$. For patients with multimorbidity, this was 44.2% (530/1199) for street health cohort vs 18.3% (420/2294) of mainstream patients, $p<0.001$.

Figure 5 shows the frequency trends of number of domains with level 3 or 4 scores[20] for patients with multimorbidity across 2+ domains for both cohorts, revealing a more pronounced and earlier onset of increased disease burden in the 25-44 and 45-64 year age group for street health patients but especially Aboriginal patients.

For the street health cohort, Aboriginal patients scored marginally higher on the CIRS Severity Index (M = 1.39, SD = 0.89) compared with non-Aboriginal patients (M = 1.34, SD = 0.91), although this difference was not statistically significant, $p=0.610$.

Factors Associated with Multimorbidity

Logistic regression analyses using the occurrence of multimorbidity across 2+, 3+ and 5+ domains as the criterion variable showed multimorbidity to be significantly associated with male gender, increasing age and Indigenous status (Table 4). Indigenous status was the strongest predictor of multimorbidity in each model. Aboriginal patients had an 87% increase in the likelihood of displaying multimorbidity across 2+ domains compared with non-Aboriginals. Aboriginal patients were also twice as likely to show multimorbidity across 3+ domains and nearly three times more likely to show multimorbidity across 5+ domains.

Table 4. Relation between socio-demographic characteristics and the prevalence of multimorbidity

Characteristic	B	SE	Odds ratio	95% CI
2+ Domains				
Male*	.36	.09	1.44	1.22 to 1.70
Age *	.04	.01	1.01	1.04 to 1.05
Indigenous*	.63	.10	1.87	1.55 to2.26
3+ Domains				
Male*	.34	.10	1.41	1.17 to 1.70
Age*	.04	.01	1.04	1.04 to 1.05
Indigenous*	.78	.10	2.17	2.17 to 2.66
5+ Domains				
Male*	.23	.14	1.26	0.96 to 1.67
Age*	.05	.01	1.05	1.04 to 1.06
Indigenous*	1.04	.15	2.82	2.11 to 3.77

* $p<.001$

DISCUSSION

Research on multimorbidity among street health populations is scarce with little data available on patterns, prevalence or disease severity among particular age or ethnic groups. Existing research has tended to focus on specific areas, such as homelessness and mental health,[27-29] with little attention on the cumulative and synergistic effects of multiple chronic conditions or a broader bio-psychosocial approach to health care needs.[4,30] The prevalence of multimorbidity is higher in deprived as opposed to more affluent areas[3,31] with multiple physical diseases often co-existing among patients with mental illness.[4,31,32]

This is the first study to use 42 conditions affecting anatomical domains to estimate patterns and prevalence of multimorbidity among marginalised and homeless patients attending a designated, primary care-run, street-based outreach service. Like our earlier mainstream practices study,[24] we include an estimation of disease severity to enhance the overall picture of multimorbidity burden in this population.

Key findings from our study include that multimorbidity is significantly associated with male gender, increasing age and Indigenous status with the latter the strongest predictor of multimorbidity irrespective of whether 2+, 3+ or 5+ domains are used as the criterion variable.

Strengths and limitations of the study

The strengths of this study include the large street health cohort size involving the total population seen over a six year period and the fact that we include a disease severity rating for each patient in addition to prevalence and patterns data recorded.

A major difficulty we encountered was enumerating the homeless population mainly because it lacked a common definition.[33] The open access policy to the street health service could have had a

diluting effect on proportion of more traditional users of the service because of one-off opportunistic and convenience attendances. Among street health patients, 22.8% had no multimorbidity compared with 26.9% among mainstream patients.

In addition, whilst the street health population is based on data collected over a six year period, the comparator mainstream practice data was collected over six months.[24]

Prevalence and patterns

Whilst multimorbidity prevalence among street health cohort is lower than mainstream cohort generally, the age breakdown across 2+ domains shows younger patients as much more vulnerable to having multiple chronic conditions with a 12% greater likelihood among 23 - 34 year old patients. This contrasts with findings from our earlier research where prevalence patterns progressively increased from the 25 – 44 year age group to the 45 – 64 and 65 -74 year age groups.[24] The reason for multimorbidity peaking in the 25 - 44 year age group in the street health population could be explained by the premature deaths of these patients or the possibility that those surviving to older age start attending mainstream practices or become institutional residents.

A key finding from our study is the willingness of Aboriginal patients to attend the street health service - 29.6% v. 1.6% to Australian primary care practices[34] – and that Aboriginal patients overall are significantly younger – 36.8% v. 18.9% under 25 years old - than non-Aboriginal patients. Among the street health population, Aboriginal patients have significantly higher rates of multimorbidity across all age groups and number of domains affected.

The high prevalence of psychiatric morbidity (46.7%) was not unexpected. The three most common domains - psychiatric, musculoskeletal (42.9%) and respiratory (35.0%) - are similar to mainstream except that psychiatry and musculoskeletal are juxtaposed.[24] These three domains remain most common even when 2+ or 3+ domains are examined and may act to facilitate or accelerate other morbidities resulting in premature ageing or progressive deterioration. The possibility that early onset of psychiatric illness may in turn contribute to a cascade of homelessness, lack of stable relationships and failure to achieve educational potential should be considered.

Disease severity

Disease severity burden is of particular value in disadvantaged populations because the cumulative and synergistic nature of their multimorbidities impacts on their need for appropriate health services[30] while their socioeconomic circumstances renders their access to such services inequitable. We found the multimorbidity SI significantly higher for street health patients, more pronounced with 'moderate' and 'severe' morbidity and persisting across all age categories. Although overall prevalence is lower in the street health cohort, where disease exists it tends to be of significantly greater severity. This is also reflected in the domain Level 3 and Level 4 scores, supporting earlier research by Starfield and Kinder[35] that morbidities are not randomly distributed amongst populations. Instead, those with the highest vulnerability to illness have a greater disadvantage because the clustering of morbidities in these sub-populations diminishes their quality of life.[3] Multimorbidity in such circumstances impacts negatively not just on their functioning status[36,37] but also causes increased and poorly co-ordinated use of health services,[5] increased direct and indirect healthcare costs[6] and heightens the risk of premature death.[38,39]

Conclusion

Our study reports on the prevalence, patterns and disease severity of multimorbidity among a marginalised population attending a primary care-led, street health clinic in Western Australia. Overall, the probability of early onset (23-34 years) multimorbidity is higher in the street health cohort compared with mainstream practice but not in patients aged over 45 years with psychiatric, musculoskeletal and respiratory the commonest domains affected. For Aboriginal patients, the prevalence of multimorbidity is higher across all ages but especially if aged < 25 years.

Disease severity is significantly higher in the street health population, especially Aboriginal patients, with greater 'moderate' and 'severe' morbidity and persists across all age categories. Attendance patterns for Aboriginal patients suggest they are more likely to engage with street-based, outreach service than mainstream practice. Reasons for this increased engagement warrant further investigation. Our findings have implications on the design and delivery of health care services to meet the increasing challenge of multimorbidity[4,40] in disadvantaged and Indigenous populations.

WHAT THIS PAPER ADDS:

What is already known on this subject

Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect health care costs and generally make poor utilisation of available health services. Mental illness, drug and alcohol abuse are especially common in homeless people. The Inverse Care Law[11] ensures that those in greatest need generally receive the least treatment.

What this study adds

Our study shows multimorbidity amongst street health patients is common, more severe and exists across all anatomical domains with younger patients (23-34 year olds) and Aboriginal patients especially vulnerable. Among the street health population, multimorbidity is significantly associated with male gender, increasing age and Indigenous status. Aboriginal patients comprise 29.6% of the street health cohort which compares favourably with the 1.6% attending mainstream Australian practices and offers hope for greater engagement of basic health services into the future.

ACKNOWLEDGEMENTS

We acknowledge the assistance of the staff at the Freo Street Doctor clinic, Fremantle Medicare Local and the medical practice involved in the study. We acknowledge the assistance of Drs Maeve Kiely and Cam Phan with data acquisition. Research support was received from The Australian Commonwealth Government Primary Health Care Research Evaluation and Development (PHCRED) Strategy Phase 2. The General Practice and Primary Health Care Research Unit is partly funded under the Collaborative Research Network (CRN) Program Grant from the Australian Government Department of Education to the University of Notre Dame Australia. We also acknowledge financial support from J Galvin, W Cunningham, L Ryan and A Neale.

CONFLICT DISCLOSURE

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: TB, DAR, LT and RGM have received research grant funding; DAR has received support from research donations; no other relationships or activities that could appear to have influenced the submitted work.

DATA SHARING STATEMENT

No additional data are available

CONTRIBUTORS

TB and DAR made substantial contributions to the conception and design of the work as well as the acquisition, analysis and interpretation of data for the study.
LT and MB made substantial contributions to the analysis and interpretation of data.
RGM made substantial contributions to the acquisition of data.
TB, DAR and LT were responsible for drafting the manuscript and all authors revised it critically for important intellectual content, final approval of the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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FIGURE LEGENDS

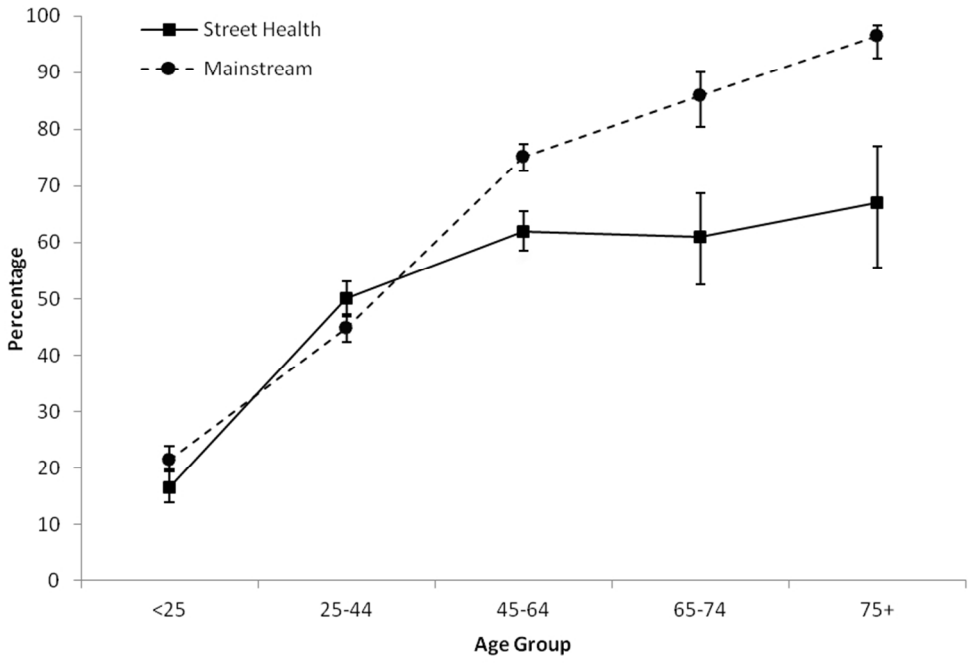
Figure 1. Prevalence of multimorbidity within age groups

Figure 2. Probability of multimorbidity (2+ domains) as a function of age

Figure 3. Prevalence of multimorbidity in Street Health sample stratified by age and Indigenous status

Figure 4. Severity Index distribution within age groups

Figure 5. Frequency trends of number of domains with Level 3 or 4 scores



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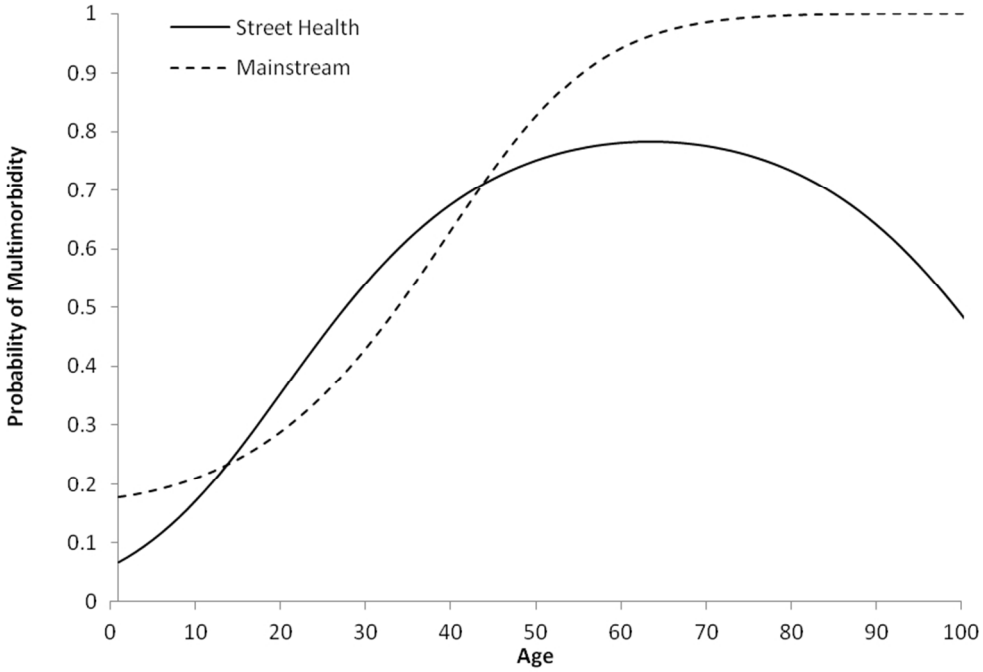

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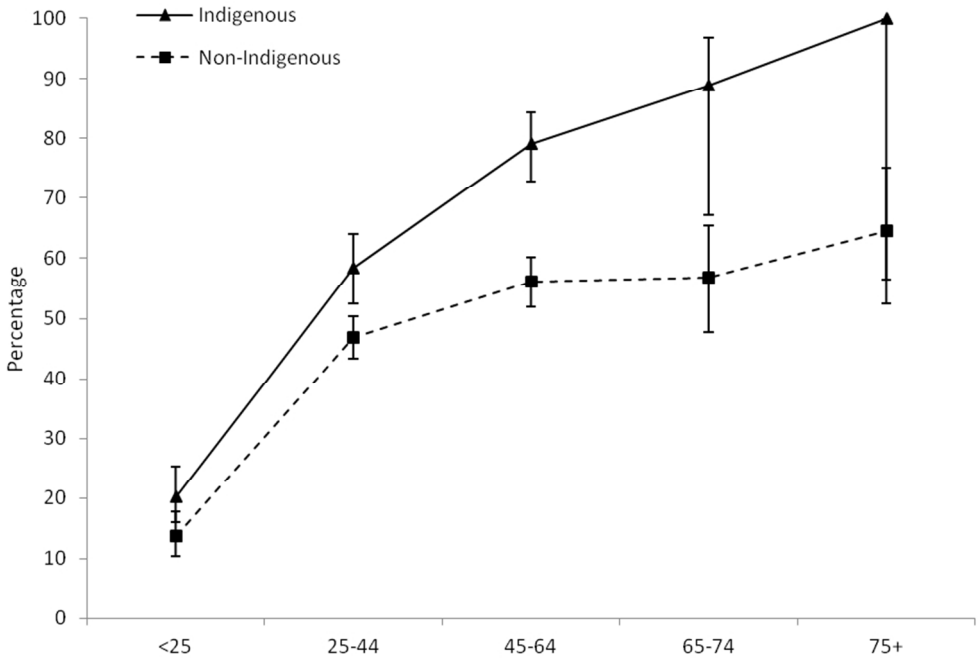

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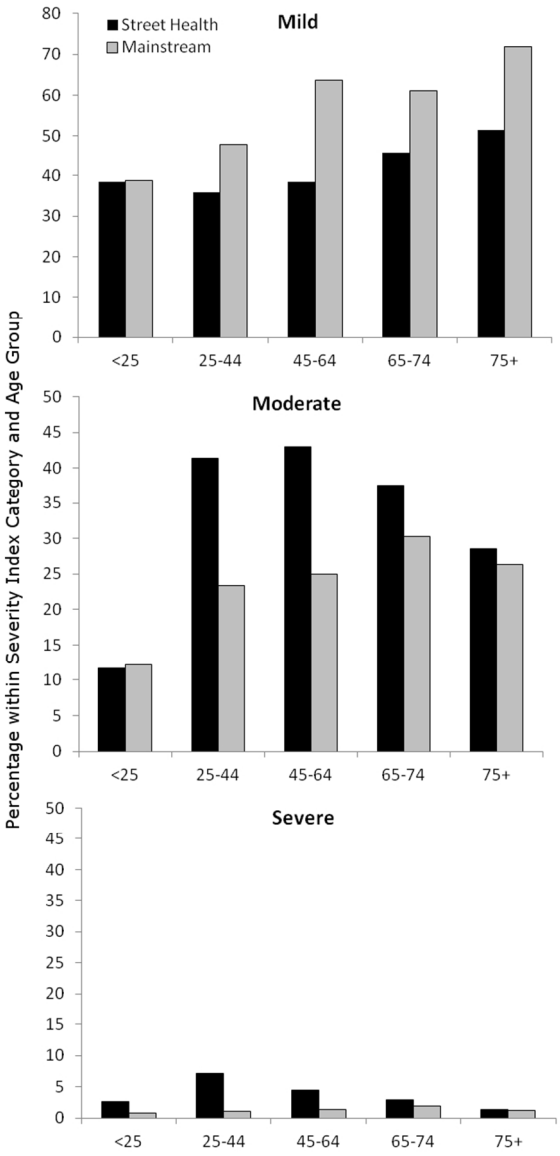

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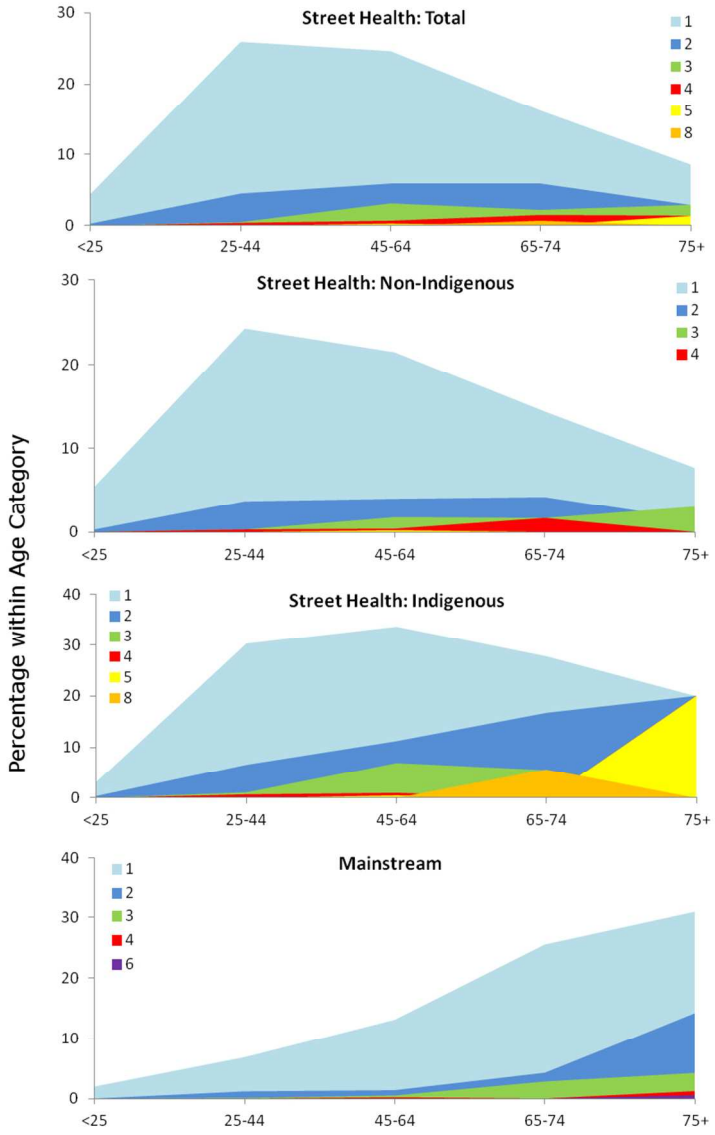

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No (Line No)
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Pg 1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Pg 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Pg 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Pg 4 (39-43)
Methods			
Study design	4	Present key elements of study design early in the paper	Pg 2 (8)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Pg 5 (7-12)
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Pg 5 (7-12)
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Pg 5 (34-35)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pg 5 (7-30)
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	Pg 5 (7-12)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pg 5 (42-56) Pg 6 (3-29)
		(*b*) Describe any methods used to examine subgroups and interactions	Pg 6 (20-23)
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A

Results			Page No (Line No)
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pg 7 (5)
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Pg 7 (4-51)
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Pg 8 (7-16)
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pg 8-12
		(*b*) Report category boundaries when continuous variables were categorized	Pg 6 (12-13)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Pg 12-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pg 12 (56) Pg 13 (3-9)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pg 14 (5-20)
Generalisability	21	Discuss the generalisability (external validity) of the study results	Pg 14 (18-19)
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Pg 14 (44-53)

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Multimorbidity in a marginalised, street-health Australian population: A retrospective cohort study

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2014-005461.R1
Article Type:	Research
Date Submitted by the Author:	05-Jun-2014
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Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	General practice / Family practice
Keywords:	PRIMARY CARE, multimorbidity, chronic disease

TITLE: Multimorbidity in a marginalised, street-health Australian population – a retrospective cohort study

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Word count (excluding title page, abstract, references, figures and tables): **3,829**

ABSTRACT

Objectives: Demographic and presentation profile of patients using an innovative mobile outreach clinic compared with mainstream practice.

Design: Retrospective cohort study.

Setting: Primary care mobile street health clinic and mainstream practice in Western Australia.

Participants: 2587 street health and 4583 mainstream patients.

Main outcome measures: Prevalence and patterns of chronic diseases in anatomical domains across entire age spectrum of patients and disease severity burden using Cumulative Illness Rating Scale (CIRS).

Results: Lower multimorbidity (2+ CIRS domains) prevalence in street health (46.3%, 1199/2587) than mainstream (50.1%, 2294/4583), *p*=0.003 when comparing crude estimates but significantly higher when comparing with direct age-sex adjusted mainstream estimate (43.1%, 2000/4583), *p*=0.011.

Higher multimorbidity in street health patients <45 years (37.7%, 615/1649) compared to mainstream patients (34.3%, 1017/2961), p=0.045 but significantly lower if 45+ years (62.3%, 584/938 vs 78.7%, 1277/1622, *p*<0.001).

Street health patients showed significantly greater disease severity. Controlling for age and gender, mean CIRS Severity Index score for street health (M = 1.4, SD = 0.91) significantly higher than mainstream patients (M = 1.1, SD = 0.80), *p*<0 .001. Furthermore, 44.2% (530/1199) of street health patients had at least one level 3 or 4 score across domains compared to 18.3% (420/2294) of mainstream patients, *p*<0.001.

Aboriginal patients were 29.6% (766/2587) of street health population with 50.4% (386/766) having multimorbidity vs 44.6% (813/1821) for non-Aboriginals, *p*=0.007. No comprehensive data on Indigenous status in mainstream cohort available for comparison.

Musculoskeletal, respiratory and psychiatric domains were most commonly affected with multimorbidity significantly associated with male gender, increasing age and Indigenous status.

Conclusions: Age-sex adjusted multimorbidity prevalence and disease severity higher in street health cohort . Early onset (23-34 years) multimorbidity is higher in street health cohort but prevalence is lower in 45+ years than mainstream patients. Multimorbidity prevalence is higher for Aboriginal patients of all ages.

ARTICLE SUMMARY

Strengths and limitations of the study

- New information on a vulnerable, street-based population accessing an accredited, mobile outreach medical service.
- The large cohort size (n=2587) involving a total street based population seen over a six year period compared with 4583 mainstream patients from similar catchment area.
- Includes a severity rating for each patient in addition to prevalence and patterns of chronic diseases recorded.
- The open access policy to the street health service could have diluted the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances.
- The street health population is based on data collected over a six year period while the comparator mainstream practice data was collected over six months.

KEY WORDS

Multimorbidity, chronic disease, primary healthcare, general practice, severity of illness index

INTRODUCTION

The combination of multiple chronic diseases (multimorbidity) and poor access to primary health care results in serious social, economic and health consequences[1-5] as well as providing considerable challenges for service providers. Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect healthcare costs[6,7] and poor utilisation of primary care health services.[1,8-11] Alcohol and drug related deaths, smoking related diseases, ischemic heart disease and respiratory diseases are especially common.[9] A systematic review[12] found homeless people in Western countries had much greater drug and alcohol dependence compared to age-matched populations while psychotic illnesses and personality disorders were also more common. Canadian homeless and marginally housed people have 32% probability of survival to 75 years among men and 60% among women with housing a key marker for socioeconomic disadvantage.[9] Death rates among 'rough sleepers' in the United Kingdom are 25 times that of the housed population.[13]

Risk factors influencing access to health services include lack of suitable housing,[9,14] mental health problems,[12,15] poor education, unemployment and lack of regular income.[16,17] Social marginalisation impacts negatively on healthcare utilisation including fear of stigmatisation on visiting mainstream practices and waiting rooms.[18] People from Indigenous, non-English speaking and refugee backgrounds often avoid contact with a regular doctor and only seek help when a crisis develops.[19-21] Such individuals have poorer health outcomes[22] exhibiting patterns of chronic, multimorbid disease at a younger age compared to the general population.[23] In Scotland, Mercer[3] found an increased burden of ill-health and multimorbidity in deprived areas resulting in greater demands on primary health care leading to reduced access, less patient-doctor time and more GP stress but less patient enablement.

The "Freo Street Doctor" is an accredited, street-based mobile health clinic established in 2005 to help meet the needs of marginalised and homeless patients unable or unwilling to access mainstream primary health care. It operates from a number of designated areas within Fremantle and surrounding suburbs in Western Australia. Whilst the target population is mainly marginalised and disadvantaged patients, access to the service is unrestricted with electronic records kept for all attendees. The clinic team consists of general practitioners, nurses, outreach workers, Indigenous health workers and social workers. Our study aims to examine the demographic profile of patients using this street health service compared to mainstream primary care practices, the range and severity of morbidities/chronic diseases across anatomical domains and compares these parameters for Aboriginal and non-Aboriginal patients.

METHOD

Study Setting

The entire patient cohort attending the "Freo Street Doctor" service over the period 1 January 2006 to 31 December 2011 was examined. Patient data was entered by reception, medical and nursing staff into standard practice software and stored centrally at Fremantle Medicare Local offices. Data for the study were extracted from the central medical records and compared with the total patient population attending a mainstream general practice clinic[24] servicing the same catchment area over the period 1 July to 31 December 2008.

Data Extraction

Data extraction was undertaken by two GPs and two medical students, all with similar training and prior experience in the use and application of the Cumulative Illness Rating Scale (CIRS). The scoring of chronic conditions using the validated CIRS has been described in detail previously[20,25] as has the Severity Index (SI) classification.[24]

Briefly, records were reviewed and 42 conditions were scored according to CIRS guidelines: 0 = no problems, 1 = mild problems, 2 = moderate morbidity, 3 = severe chronic problems, 4 = extremely severe functional impairment. Conditions were categorised into 14 anatomical domains. Maximum scores for each domain were added to yield a total score ranging from 0 to 56 for each patient. The total score was then divided by the number of domains with morbidities to generate a CIRS score for each patient ranging from 0 to 4. Severity ratings were defined as 0 = none/low, 1 = mild, 2 = moderate and 3/4 = severe.

The street health dataset contained a large number of one-off consultations. Some attendees had no fixed abode with many using drop-in centres as proxy addresses. As far as possible, data extractors took precautions to guard against double counting. There may have been some limited cross over between street and mainstream practices but, in general, patients attending one service tended to continue doing so.

Operational Definition

Our operational definition of multimorbidity was the co-occurrence of conditions across two or more (2+) domains in individual patients.[26] After data extraction was completed, a random sample of 30 patients across the entire age spectrum for both clinics was re-assessed to measure consistency among raters.

Data Analysis

Data analysis was conducted using SPSS 22 (IBM Corporation). All statistical analyses were tested against an alpha level of 0.05 (two-tailed).

Sample characteristics are expressed as means (standard deviation of the mean) for continuous variables and as frequencies (percentages) for categorical variables. Independent samples t-tests and Chi-Square tests were used to examine any demographic differences between the two samples.

The crude prevalence of multimorbidity was calculated as the number of patients with long-term conditions in 2+ morbidity domains as a proportion of the total sample. Given significant differences in age-sex distribution between the two samples, age-sex adjusted prevalence was calculated for the mainstream sample using direct standardisation to the street health cohort. Chi-square tests were used to examine prevalence differences between the two cohorts. Patterns of multimorbidity are expressed as frequencies.

In addition, to examine age of onset of multimorbidity, we modelled the probability of multimorbidity as a function of age. First, a logistic regression analysis was run with the presence of multimorbidity as the dependent variable, and clinic, age, and age squared (given the non-linear relationship between age and multimorbidity) as independent variables (IV). The regression coefficients (β) for each IV were then used to model the probability of multimorbidity as a function of age in each sample.

Multimorbidity severity was examined using the CIRS SI score as well as distribution of patients within each CIRS severity category. General linear modelling (GLM) was used to examine differences in multimorbidity severity between the two samples, controlling for age and gender. We also counted and compared the number of patients with at least one level 3 or 4 score across CIRS domains,[20] as well as the number of domains with a level 3 or 4 score for each patient as additional indicators of disease severity.

Subgroup analysis was conducted to examine the prevalence and severity of multimorbidity in Indigenous and non-Indigenous patients in the street health cohort. There was no data on Indigenous status in the mainstream cohort for comparison.

We also examined the relationship between demographic characteristics and the presence of multimorbidity across 2, 3, and 5 domains using a series of logistic regression analyses.

Inter-rater reliability between data extractors was assessed using Cronbach's alpha.

Ethics

Ethics approval for the study was obtained from The University of Notre Dame Australia Human Research Ethics Committee.

RESULTS

Patient Characteristics

A total of 2587 patients attended the street health service and 4583 attended mainstream practice over the study periods. The age and gender distribution of patients at both clinics are shown in Table 1. The mean age of street health patients was 37.8 years (SD = 18.7) compared with 36.2 (SD = 21.1) for the mainstream practice. There were no significant differences in age between the two cohorts, p=0.055, but a significant difference in gender distribution was observed. The majority of the street health patients were male (57.3%, 1482/2587) while the majority of patients attending mainstream practice were female (60.7%, 2783/4583), p<0.001.

Table 1. Age and Gender Distribution for Study Population

	Fremantle Street Doctor			Mainstream practice (n = 4583)
	Overall (n = 2587)	Aboriginal (n = 766)	Non-Aboriginal (n = 1821)	
Sex, % (n)				
Male	57.3 (1482)	50.3 (385)	60.2 (1097)	39.3 (1800)
Female	42.7 (1105)	49.7 (381)	39.8 (724)	60.7 (2783)
Age, mean (SD) [range]				
Overall	37.8 (18.7) [0 to 103]	32.09 (17.9) [0 to 81]	40.19 (18.5) [0 to 103]	36.18 (21.1) [0 to 98]
Male	39.1 (18.5) [0 to 103]	31.8 (18.1) [1 to 81]	41.6 (17.9) [0 to 103]	35.1 (22.3) [0 to 92]
Female	36.1 (18.7) [0 to 90]	32.3 (17.7) [0 to 75]	38.0 (18.9) [0 to 90]	36.9 (20.3) [0 to 98]
Age Category, % (n)				
< 25	24.2 (626)	36.8 (282)	18.9 (344)	28.9 (1326)
25 to 44	39.5 (1023)	35.8 (274)	41.1 (749)	35.7 (1635)
45 to 64	28.3 (732)	24.4 (187)	29.9 (545)	27.1 (1243)
65 to 74	5.3 (136)	2.3 (18)	6.5 (118)	4.6 (211)
75+	2.7 (70)	0.7 (5)	3.6 (65)	3.7 (168)

Aboriginal patients were 29.6% (766/2587) of the street health sample. On average, Aboriginal patients were significantly younger than non-Aboriginal patients, with 36.8% (282/766) under the age of 25 compared with only 18.9% (344/1821) of non-Aboriginals, p<0.001. The majority of non-Aboriginal patients were male (60.2%, 1097/1821) while there was a more even gender distribution for Aboriginal patients attending the street health service (male 50.3%, 385/766), p<0.001.

Inter-rater Reliability

Inter-rater reliability between data extractors was tested on CIRS scores and number of domains with morbidities for 30 randomly selected patients from each of the two cohorts. For the street health cohort, the intraclass correlation coefficient (ICC) was 0.94 (95% confidence interval 0.89 to 0.97) for number of domains with morbidities and 0.96 (95% CI 0.93 to 0.98) for total CIRS scores indicating high inter-rater reliability. For the mainstream practice sample, the ICC was 0.98 (95% CI 0.97 to 0.99) for number of domains with morbidities and 0.98 (95% CI 0.97 to 0.99) for CIRS scores.

Prevalence of Multimorbidity

Overall, the crude prevalence of multimorbidity was lower in the street health sample. Multimorbidity, based on the presence of conditions affecting 2+ domains, was present in 46.3% (1199/2587, 95% confidence interval 44.4 to 48.3%) of street health patients, compared with 50.1% (2294/4583, 95% CI 48.6 to 51.5%) of the mainstream sample, p=0.003. A total of 28.0% (724/2587) of the street health cohort had multimorbidity in 3+ domains compared with 31.9% (1464/4583) of mainstream patients, p<0.001. Across 5+ domains, 10% (259/2587) of street health patients showed multimorbidity compared with 12.8% (587/4583) of the mainstream sample, p<0.001.

Figure 1 shows the crude prevalence of multimorbidity across 2+ domains for both samples across age groups. The prevalence of multimorbidity among young street health patients aged < 45 years (37.7%, 615/1649) was significantly higher than in the mainstream sample (34.3%, 1017/2961), p=0.045. Multimorbidity prevalence was significantly lower in the street health sample for patients 45+ years (62.3% [584/938] vs 78.7% [1277/1622], respectively), p<0.001.

After direct age-sex adjustment of the mainstream prevalence rate, the prevalence of multimorbidity was significantly higher in the street health (46.3%, 1199/2587) than mainstream sample (43.1%, 2000/4583), p=0.011.

Age of onset of multimorbidity was different for the two populations (Figure 2). For street health patients, the probability of multimorbidity peaked between 61 and 67 years, P ($E_{\text{STREET HEALTH}}$)= 0.78, and then decreased. For mainstream patients, the probability of multimorbidity increased with age, with the greatest probability of multimorbidity observed for individuals aged over 70 years, P ($E_{MAINSTREAM}$)= 0.99. Between the ages of 14 and 43, the probability of multimorbidity was higher for street health patients, P ($E_{\text{STREET HEALTH}}$) = 0.26 to 0.71 vs. P ($E_{\text{MAINSTREAM}}$) = 0.24 to 0.69, suggesting that younger street health patients are particularly vulnerable to multimorbidity. The greatest difference was observed between the ages of 23 and 34, P ($E_{\text{STREET HEALTH}}$) = 0.43 to 0.62 vs. P ($E_{\text{MAINSTREAM}}$) = 0.33

to 0.52, with street health patients showing a mean 12% greater chance of multimorbidity than mainstream patients in this age group.

Overall for the street health Aboriginal patients, multimorbidity (2+ domains) was present in 50.4% (386/765, 95% confidence interval 46.9 to 53.9%) compared with 44.6% (813/1821, 95% CI 42.4 to 46.9%) in non-Aboriginals, *p=0.0*07. A total of 33.2% of Aboriginal patients (254/766) had 3+ domains affected compared with 25.8% (470/1821) in non-Aboriginals, $p<0.001$, while 13.7% (105/765) had 5+ domains affected compared with 8.5% (154/1821) in non-Aboriginals, $p<0.001$. Stratified by age, the prevalence of multimorbidity (2+) across all age groups was significantly higher among Aboriginal compared with non-Aboriginal patients, $p<0.001$ (Figure 3).

Patterns of Multimorbidity

Table 2 displays the prevalence of the five most common body system domain combinations across single, 1+, 2+, 3+ and 5+ domains for the street health sample with corresponding prevalence rates in mainstream practice for comparison. Table 2 also displays the prevalence of the five most common domain combinations stratified by age.

Table 3 displays the prevalence of the five most common domain combinations across single, 1+, 2+, 3+ and 5+ domains stratified by Indigenous status and age.

Consistent with the CIRS guidelines, patients with conditions that appeared to be ongoing (for example, leg ulcers, non-healing skin infections and lacerations and scabies infestation) were included in the musculoskeletal/integumental domain.

Table 2. Overall and age category breakdown for the 5 most common domains for Street Health cohort

	Domains	Street Health % (*n*)	Mainstream practice % (*n*)[a-d]	Age category (Street health cohort only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 798)	Musculoskeletal	29.8 (238)**	21.8 (231)	24.2 (58)	49.2 (117)	19.7 (47)	5.9 (14)	0.8 (2)
	Psychiatric	20.3 (162)	18.7 (198)	20.4 (33)	53.7 (87)	24.1 (39)	1.9 (3)	0
	Eye, ear, nose and throat	13.7 (109)*	9.7 (103)	62.4 (68)	18.3 (20)	14.7 (16)	0.9 (1)	3.7 (4)
	Respiratory	9.4 (75)	17.8 (188)	38.7 (29)	29.3 (22)	30.7 (23)	1.3 (1)	0
	Genitourinary	6.9 (55)	8.5 (90)	14.5 (8)	69.1 (38)	14.5 (8)	1.8 (1)	0
One or more domains (*n* = 1997)	Psychiatric	46.7 (933)**	34.6 (1161)	8.6 (80)	48.9 (456)	36.5 (341)	4.7 (44)	1.3 (12)
	Musculoskeletal	42.9 (856)	45.2 (1514)	13.1 (112)	44.6 (382)	31.8 (272)	7.1 (61)	3.4 (29)
	Respiratory	35.0 (699)	35.6 (1193)	11.7 (82)	43.2 (302)	38.6 (270)	4.9 (34)	1.6 (11)
	Eye, ear, nose and throat	19.1 (381)*	22.7 (762)	29.4 (112)	29.7 (113)	29.7 (113)	6.3 (24)	5.0 (19)
	Vascular	18.2 (364)**	22.3 (746)	3.3 (12)	17.6 (64)	53.8 (196)	13.5 (49)	11.8 (43)
Two or more domains (*n* = 1199)	Psychiatric + Respiratory	37.1 (445)**	18.8 (432)	7.2 (32)	48.3 (215)	39.1 (174)	4.3 (19)	1.1 (5)
	Psychiatric + Musculoskeletal	32.4 (388)**	22.2 (510)	3.6 (14)	47.2 (183)	41.8 (162)	5.7 (22)	1.8 (7)
	Respiratory + Musculoskeletal	25.6 (307)*	22.4 (515)	5.9 (18)	42.3 (130)	43.3 (133)	6.8 (21)	1.6 (5)
	Vascular + Musculoskeletal	14.6 (175)**	19.4 (445)	2.3 (4)	17.7 (31)	50.9 (89)	15.4 (27)	13.7 (24)
	Hepatic-Pancreatic + Psychiatric	14.3 (172)**	2.8 (64)	1.7 (3)	45.9 (79)	45.9 (79)	5.3 (9)	1.2 (2)
Three or more domains (*n* = 724)	Psychiatric + Respiratory + Musculoskeletal	30.9 (224)**	14.7 (215)	3.6 (8)	42.4 (95)	47.3 (106)	5.8 (13)	0.9 (2)
	Psychiatric + Haematological + Endocrine	14.5 (105)	14.1 (206)	3.8 (4)	37.1 (39)	46.7 (49)	8.6 (9)	3.8 (4)
	Psychiatric + Respiratory + Vascular	14.4 (104)**	8.5 (125)	2.9 (3)	25.0 (26)	60.6 (63)	8.7 (9)	2.9 (3)
	Psychiatric + Musculoskeletal + Vascular	14.2 (103)	13.1 (192)	1.0 (1)	18.4 (19)	60.2 (62)	14.6 (15)	5.8 (6)
	Psychiatric + Respiratory + Lower Gastrointestinal	13.8 (100)**	5.9 (87)	1.0 (1)	46.0 (46)	50.0 (50)	1.0 (1)	2.0 (2)

[a] For 1 domain only, denominator (n = 1058), [b] For 1+ domains, denominator (n = 3352), [c] For 2+ domains, denominator (n = 2294), [d] For 3+ domains, denominator (n = 1772)

* Chi square test significant at .05 level vs mainstream practice

** Chi square test significant at .001 level vs mainstream practice

Table 3. Overall and age category breakdown for the 5 most common domains for Aboriginal Street Health patients

	Domains	Aboriginal % (*n*)	Non-Aboriginal % (*n*) [a-d]	Age category (Aboriginal patients only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 216)	Musculoskeletal	34.3 (74)	28.2 (164)	55.4 (41)	36.5 (27)	8.1 (6)	0	0
	Eye, ear, nose and throat	19.0 (41)*	11.7 (68)	85.4 (35)	12.2 (5)	2.4 (1)	0	0
	Psychiatric	13.0 (28)*	23.0 (134)	25.0 (7)	57.1 (16)	17.9 (5)	0	0
	Respiratory	8.3 (18)	9.8 (57)	55.6 (10)	22.2 (4)	22.2 (4)	0	0
	Lower gastrointestinal	6.0 (13)	5.0 (29)	30.8 (4)	53.8 (7)	15.4 (2)	0	0
One or more domains (*n* = 602)	Musculoskeletal	47.5 (286)*	40.9 (570)	25.9 (74)	40.2 (115)	30.1 (86)	3.1 (9)	0.7 (2)
	Psychiatric	45.5 (274)	47.2 (659)	10.6 (29)	47.8 (131)	37.2 (102)	4.0 (11)	0.4 (1)
	Respiratory	38.7 (233)*	33.4 (466)	16.3 (38)	42.5 (99)	36.9 (86)	3.4 (8)	0.9 (2)
	Eye, ear, nose and throat	24.9 (150)**	16.6 (231)	42.0 (63)	27.3 (41)	24.7 (37)	4.0 (6)	2.0 (3)
	Endocrine	24.4 (147)**	13.3 (186)	7.5 (11)	34.0 (50)	46.9 (69)	8.8 (13)	2.7 (4)
Two or more domains (*n* = 386)	Psychiatric + Respiratory	39.6 (153)	35.9 (292)	9.8 (15)	47.7 (73)	38.6 (59)	3.3 (5)	0.7 (1)
	Psychiatric + Musculoskeletal	35.2 (136)	31.0 (252)	5.1 (7)	46.3 (63)	44.1 (60)	4.4 (6)	0
	Respiratory + Musculoskeletal	31.3 (121)*	22.9 (186)	9.1 (11)	42.1 (51)	43.8 (53)	4.1 (5)	0.8 (1)
	Respiratory + Endocrine	20.2 (78)**	7.7 (63)	5.1 (4)	35.9 (28)	50.0 (39)	7.7 (6)	1.3 (1)
	Psychiatric + Endocrine	19.2 (74)**	10.2 (83)	5.4 (4)	36.5 (27)	47.3 (35)	9.5 (7)	1.4 (1)
Three or more domains (*n* = 254)	Psychiatric + Respiratory + Musculoskeletal	35.8 (91)*	28.3 (133)	5.5 (5)	44.0 (40)	47.3 (43)	3.3 (3)	0
	Psychiatric + Haematological + Endocrine	22.4 (57)**	10.2 (48)	3.5 (2)	40.4 (23)	47.4 (27)	7.0 (4)	1.8 (1)
	Respiratory + Musculoskeletal + Endocrine	18.9 (48)**	7.4 (35)	2.1 (1)	31.3 (15)	60.4 (29)	6.3 (3)	0
	Vascular + Respiratory + Endocrine	18.5 (47)**	6.8 (32)	0	27.7 (13)	63.8 (30)	6.4 (3)	2.1 (1)
	Psychiatric + Vascular + Respiratory	18.1 (46)*	12.3 (58)	2.2 (1)	28.3 (13)	65.2 (30)	2.2 (1)	2.2 (1)

[a] For 1 domain only, denominator (n = 582), [b] For 1+ domains, denominator (n = 1395), [c] For 2+ domains, denominator (n = 813), [d] For 3+ domains, denominator (n = 470)

* Chi square test significant at .05 level vs Non-Aboriginal

** Chi square test significant at .001 level vs Non-Aboriginal

Multimorbidity Severity Index

Overall, GLM analysis revealed a significantly greater severity of disease among the street health cohort. Controlling for age and gender, street health patients (M = 1.4, SD = .91) had significantly higher multimorbidity severity than mainstream patients (M = 1.1, SD = .80), $p<0.001$.

A significantly greater proportion of the street health patients were represented in the moderate (34.1%, 883/2587, 95% confidence interval 32.3 to 35.9%), $p<0.001$, and severe categories (4.9%, 126/2587, 95% CI 4.1 to 5.8%), $p<0.001$, compared with mainstream patients (moderate: 21.0%, 961/4583, 95% CI 19.8 to 22.2%; severe: 1.2%, 53/4583, 95% CI, 0.9 to 1.5%). When multimorbidity severity was stratified by age (Figure 4), a greater proportion of street health patients were again represented in the moderate and severe categories across every age category.

Overall, 24.4% (632/2587) of street health patients compared to 10.1% (463/4583) of mainstream patients had at least one level 3 or level 4 score across domains, $p<0.001$. For patients with multimorbidity, this was 44.2% (530/1199) for street health cohort vs 18.3% (420/2294) of mainstream patients, $p<0.001$.

Figure 5 shows the frequency trends of number of domains with level 3 or 4 scores[20] for patients with multimorbidity across 2+ domains for both cohorts, revealing a more pronounced and earlier onset of increased disease burden in the 25-44 and 45-64 year age group for street health patients but especially Aboriginal patients.

For the street health cohort, Aboriginal patients scored marginally higher on the CIRS Severity Index (M = 1.39, SD = 0.89) compared with non-Aboriginal patients (M = 1.34, SD = 0.91), although this difference was not statistically significant, $p=0.610$.

Factors Associated with Multimorbidity

Logistic regression analyses using the occurrence of multimorbidity across 2+, 3+ and 5+ domains as the criterion variable showed multimorbidity to be significantly associated with male gender, increasing age and Indigenous status (Table 4). Indigenous status was the strongest predictor of multimorbidity in each model. Aboriginal patients had an 87% increase in the likelihood of displaying multimorbidity across 2+ domains compared with non-Aboriginals. Aboriginal patients were also twice as likely to show multimorbidity across 3+ domains and nearly three times more likely to show multimorbidity across 5+ domains.

Table 4. Relation between socio-demographic characteristics and the prevalence of multimorbidity

Characteristic	Odds ratio	95% CI
2+ Domains		
Male*	1.44	1.22 to 1.70
Age *	1.01	1.04 to 1.05
Indigenous*	1.87	1.55 to2.26
3+ Domains		
Male*	1.41	1.17 to 1.70
Age*	1.04	1.04 to 1.05
Indigenous*	2.17	2.17 to 2.66
5+ Domains		
Male*	1.26	0.96 to 1.67
Age*	1.05	1.04 to 1.06
Indigenous*	2.82	2.11 to 3.77

* $p<.001$

DISCUSSION

Research on multimorbidity among street health populations is scarce with little data available on patterns, prevalence or disease severity among particular age or ethnic groups. Existing research has tended to focus on specific areas, such as homelessness and mental health,[27-29] with little attention on the cumulative and synergistic effects of multiple chronic conditions or a broader bio-psychosocial approach to health care needs.[4,30] The prevalence of multimorbidity is higher in deprived as opposed to more affluent areas[3,31] with multiple physical diseases often co-existing among patients with mental illness.[4,31,32]

This is the first study to use 42 conditions affecting anatomical domains to estimate patterns and prevalence of multimorbidity among marginalised and homeless patients attending a designated, primary care-run, street-based outreach service. Like our earlier mainstream practices study,[24] we include an estimation of disease severity to enhance the overall picture of multimorbidity burden in this population.

Key findings from our study include that multimorbidity is significantly associated with male gender, increasing age and Indigenous status with the latter the strongest predictor of multimorbidity irrespective of whether 2+, 3+ or 5+ domains are used as the criterion variable.

Strengths and limitations of the study

The strengths of this study include the large street health cohort size involving the total population seen over a six year period and the fact that we include a disease severity rating for each patient in addition to prevalence and patterns data recorded.

A major difficulty we encountered was enumerating the homeless population mainly because it lacked a common definition.[33] The open access policy to the street health service could have had a diluting effect on the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances. Among street health patients, 22.8% had no multimorbidity compared with 26.9% among mainstream patients.

In addition, whilst the street health population is based on data collected over a six year period, the comparator mainstream practice data was collected over six months.[24]

Prevalence and patterns

Multimorbidity prevalence among the street health cohort was significantly higher than the age-sex adjusted prevalence for the mainstream cohort. The age breakdown across 2+ domains shows younger patients as much more vulnerable to having multiple chronic conditions with a 12% greater likelihood among 23 - 34 year old patients. This contrasts with findings from our earlier research where prevalence patterns progressively increased from the 25 – 44 year age group to the 45 – 64 and 65 -74 year age groups.[24] The reason for multimorbidity peaking in the 25 - 44 year age group in the street health population could be explained by the premature deaths of these patients or the possibility that those surviving to older age start attending mainstream practices or become institutional residents.

A key finding from our study is the willingness of Aboriginal patients to attend the street health service - 29.6% v. 1.6% to Australian primary care practices[34] – and that Aboriginal patients overall are significantly younger – 36.8% v. 18.9% under 25 years old - than non-Aboriginal patients. Due to a lack of data on Aboriginality amongst the mainstream practice, it was not possible to compare both cohorts. Among the street health population, Aboriginal patients have significantly higher rates of multimorbidity across all age groups and number of domains affected.

The high prevalence of psychiatric morbidity (46.7%) was not unexpected. The three most common domains - psychiatric, musculoskeletal (42.9%) and respiratory (35.0%) - are similar to mainstream except that psychiatry and musculoskeletal are juxtaposed.[24] These three domains remain most common even when 2+ or 3+ domains are examined and may act to facilitate or accelerate other morbidities resulting in premature ageing or progressive deterioration.

A notable feature of the street population was the high prevalence of chronic skin conditions (leg ulcers, slow to heal infections/lacerations and scabies) reflecting the reality of poor living circumstances and hygiene. Inclusion of these conditions as part of the musculoskeletal/integumental domain is likely to have increased the overall prevalence for this domain. The possibility that early onset of psychiatric illness may in turn contribute to a cascade of homelessness, lack of stable relationships and failure to achieve educational potential should be considered.

Disease severity

Disease severity burden is of particular value in disadvantaged populations because the cumulative and synergistic nature of their multimorbidities impacts on their need for appropriate health services[30] while their socioeconomic circumstances renders their access to such services inequitable. American, [10] Canadian[9] and British[12,13] studies have all found much common ground with housing, mental illness, poor education and smoking common factors throughout. Complex interventions invariably do better when housing is integrated into the solution and the importance of social geography and family supports acknowledged.[7] There is no definitive answer but well integrated support networks built around primary care services would appear a logical way forward.

We found the multimorbidity SI significantly higher for street health patients, more pronounced with 'moderate' and 'severe' morbidity and persisting across all age categories. Given the large numbers in the two population cohorts, the relatively small but significant differences of 13% in the moderately severe and 4% in the severe disease severity index categories translate to a substantial number of patients. The impost in terms of service delivery could therefore be greater than is primarily evident. Taken together with the fact that the presence of multiple severe or moderately severe chronic conditions is not compatible with long-term survival or management in the primary care setting especially amongst a marginalised, street health population, it is likely to impact directly on Emergency Department visits and hospital admissions.

After age-sex adjustment, multimorbidity prevalence is significantly higher among the street health cohort. Where disease exists, it tends to be of significantly greater severity as reflected by the more pronounced domain level 3 and level 4 scores. This supports earlier research by Starfield and Kinder[35] that morbidities are not randomly distributed amongst populations. Instead, those with the highest vulnerability to illness have a greater disadvantage because the clustering of morbidities

in these sub-populations diminishes their quality of life.[3] Multimorbidity in such circumstances impacts negatively not just on their functioning status[36,37] but also causes increased and poorly co-ordinated use of health services,[5] increased direct and indirect healthcare costs[6] and heightens the risk of premature death.[38,39]

Conclusion

Our study reports on the prevalence, patterns and disease severity of multimorbidity among a marginalised population attending a primary care-led, street health clinic in Western Australia. Overall, the probability of early onset (23-34 years) multimorbidity is higher in the street health cohort compared with mainstream practice but not in patients aged over 45 years with psychiatric, musculoskeletal and respiratory the commonest domains affected. For Aboriginal patients, the prevalence of multimorbidity is higher across all ages but especially if aged < 25 years.

Disease severity is significantly higher in the street health population, especially Aboriginal patients, with greater 'moderate' and 'severe' morbidity and persists across all age categories. Attendance patterns for Aboriginal patients suggest they are more likely to engage with street-based, outreach service than mainstream practice. Reasons for this increased engagement warrant further investigation.

Our findings have implications on the design and delivery of health care services to meet the increasing challenge of multimorbidity[4,40] in disadvantaged and Indigenous populations. Traditional approaches to service delivery fail to meet the needs of this population.[12] Such services need more complex interventions but are unlikely to receive appropriate health services expenditure and compare unfavourably with that offered to mainstream patients. A more integrated outreach approach involving better housing, psychiatric, education and social supports would seem logical to address their needs. Longer term prospective studies including an economic analysis component would be helpful.

WHAT THIS PAPER ADDS:

What is already known on this subject

Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect health care costs and generally make poor utilisation of available health services. Mental illness, drug and alcohol abuse are especially common in homeless people. The Inverse Care Law[11] ensures that those in greatest need generally receive the least treatment.

What this study adds

Our study shows multimorbidity amongst street health patients is common, more severe and exists across all anatomical domains with younger patients (23-34 year olds) and Aboriginal patients especially vulnerable. Among the street health population, multimorbidity is significantly associated with male gender, increasing age and Indigenous status. Aboriginal patients comprise 29.6% of the street health cohort which compares favourably with the 1.6% attending mainstream Australian practices and offers hope for greater engagement of basic health services into the future.

ACKNOWLEDGEMENTS

We acknowledge the assistance of the staff at the Freo Street Doctor clinic, Fremantle Medicare Local and the medical practice involved in the study. We acknowledge the assistance of Drs Maeve Kiely and Cam Phan with data acquisition. Research support was received from The Australian Commonwealth Government Primary Health Care Research Evaluation and Development (PHCRED) Strategy Phase 2. The General Practice and Primary Health Care Research Unit is partly funded under the Collaborative Research Network (CRN) Program Grant from the Australian Government Department of Education to the University of Notre Dame Australia. We also acknowledge financial support from J Galvin, W Cunningham, L Ryan and A Neale.

FUNDING

Research support was received from The Australian Commonwealth Government Primary Health Care Research Evaluation and Development (PHCRED) Strategy Phase 2. The General Practice and Primary Health Care Research Unit is partly funded under the Collaborative Research Network (CRN) Program Grant from the Australian Government Department of Education to the University of Notre Dame Australia. We also acknowledge financial support from J Galvin, W Cunningham, L Ryan and A Neale.

CONFLICT DISCLOSURE

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: TB, DAR, LT and RGM have received research grant funding; DAR has received support from research donations; no other relationships or activities that could appear to have influenced the submitted work.

DATA SHARING STATEMENT

No additional data are available

CONTRIBUTORS

TB and DAR made substantial contributions to the conception and design of the work as well as the acquisition, analysis and interpretation of data for the study.

LT and MB made substantial contributions to the analysis and interpretation of data.

RGM made substantial contributions to the acquisition of data.

TB, DAR and LT were responsible for drafting the manuscript and all authors revised it critically for important intellectual content, final approval of the version to be published and agree to be

accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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FIGURE LEGENDS

Figure 1. Prevalence of multimorbidity within age groups with 95% confidence intervals

Figure 2. Probability of multimorbidity (2+ domains) as a function of age

Figure 3. Prevalence of multimorbidity in Street Health sample stratified by age and Indigenous status with 95% confidence intervals

Figure 4. Severity Index distribution within age groups

Figure 5. Frequency trends of number of domains with level 3 or 4 scores

TITLE: Multimorbidity in a marginalised, street-health Australian population – a retrospective cohort study

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Word count (excluding title page, abstract, references, figures and tables): **3,829**

ABSTRACT

Objectives: ~~To examine the d~~Demographic and presentation profile of patients using an innovative mobile outreach clinic ~~and~~ compared ~~this service~~ with ~~patients attending~~ mainstream practice.

Design: Retrospective cohort study.

Setting: ~~Two p~~Primary care ~~clinics in Western Australia:~~ mobile street health clinic and mainstream practice in Western Australia.

Participants: 2587 street health ~~patients~~ and 4583 mainstream patients.

Main outcome measures: Prevalence and patterns of chronic diseases in anatomical domains across entire age spectrum of patients and disease severity burden using Cumulative Illness Rating Scale (CIRS).

Results: ~~The crude~~Lower ~~prevalence of~~ ~~Multimorbidity~~ multimorbidity (2+ CIRS domains) prevalence ~~was lower~~ in ~~the~~ street health (46.43%, 1199/2587) than mainstream ~~sample~~ (50.1%, 2294/4583), *p*=0.003 when comparing crude estimates but significantly higher when comparing with ~~. However, after~~ direct age-sex adjust~~mented of the~~ mainstream ~~prevalence rate~~estimate (43.1%, 2000/4583), ~~multimorbidity prevalence was significantly higher in the street health than mainstream sample,~~ *p*=0.011.

~~Younger street health patients (14-43 years) showed greater~~Higher multimorbidity in street health patients <45 years (37.7%, 615/1649) compared to ~~than~~ mainstream patients (34.3%, 1017/2961), p=0.045 but ~~. Prevalence is~~ significantly lower if 45+ years ~~in street health~~ (62.3%, 584/938 vs 78.7%, 1277/1622, *p*<0.001) ~~if aged 45+ years compared to mainstream patients (78.7%, 1277/1622), p<0.001.~~

~~but s~~Street health patients ~~also~~ showed significantly greater disease severity. Controlling for age and gender, mean CIRS Severity Index score for street health (M = 1.4, SD = 0.91) ~~was~~ significantly higher than mainstream patients (M = 1.1, SD = 0.80), *p*<0 .001. Furthermore, 44.2% (530/1199) of street health patients had at least one level 3 or 4 score across domains compared to 18.3% (420/2294) of mainstream patients, *p*<0.001.

~~Younger street health patients (14-43 years) showed greater multimorbidity than mainstream patients. Prevalence is significantly lower in street health (62.3%, 584/938) if aged 45+ years compared to mainstream patients (78.7%, 1277/1622), $p<0.001$.~~

Aboriginal patients were 29.6% (766/2587) of street health population with 50.4% (386/766) having multimorbidity ~~compared with~~vs 44.6% (813/1821) for non-Aboriginals, $p=0.007$. ~~There was n~~No comprehensive data on Indigenous status in ~~the~~ mainstream cohort available for comparison.

Musculoskeletal, respiratory and psychiatric domains were most commonly affected with multimorbidity significantly associated with male gender, increasing age and Indigenous status.

Conclusions: Age-sex adjusted ~~Multimorbidity~~ multimorbidity prevalence and disease severity ~~is lower~~ higher in street health cohort ~~but with greater severity~~. Early onset (23-34 years ~~old~~) multimorbidity is higher in street health cohort but prevalence is lower in 45+ years than mainstream patients. Multimorbidity prevalence is higher for Aboriginal patients of all ages.

ARTICLE SUMMARY

Strengths and limitations of the study

- New information on a vulnerable, street-based population accessing an accredited, mobile outreach medical service.
- The large cohort size (n=2587) involving a total street based population seen over a six year period compared with 4583 mainstream patients from similar catchment area.
- Includes a severity rating for each patient in addition to prevalence and patterns of chronic diseases recorded.
- The open access policy to the street health service could have diluted the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances.
- The street health population is based on data collected over a six year period while the comparator mainstream practice data was collected over six months.

KEY WORDS

Multimorbidity, chronic disease, primary healthcare, general practice, severity of illness index

INTRODUCTION

The combination of multiple chronic diseases (multimorbidity) and poor access to primary health care results in serious social, economic and health consequences[1-5] as well as providing considerable challenges for service providers. Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect healthcare costs[6,7] and poor utilisation of primary care health services.[1,8-11] Alcohol and drug related deaths, smoking related diseases, ischemic heart disease and respiratory diseases are especially common.[9] A systematic review[12] found homeless people in Western countries had much greater drug and alcohol dependence compared to age-matched populations while psychotic illnesses and personality disorders were also more common. Canadian homeless and marginally housed people have 32% probability of survival to 75 years among men and 60% among women with housing a key marker for socioeconomic disadvantage.[9] Death rates among 'rough sleepers' in the United Kingdom are 25 times that of the housed population.[13]

Risk factors influencing access to health services include lack of suitable housing,[9,14] mental health problems,[12,15] poor education, unemployment and lack of regular income.[16,17] Social marginalisation impacts negatively on healthcare utilisation including fear of stigmatisation on visiting mainstream practices and waiting rooms.[18] People from Indigenous, non-English speaking and refugee backgrounds often avoid contact with a regular doctor and only seek help when a crisis develops.[19-21] Such individuals have poorer health outcomes[22] exhibiting patterns of chronic, multimorbid disease at a younger age compared to the general population.[23] In Scotland, Mercer[3] found an increased burden of ill-health and multimorbidity in deprived areas resulting in greater demands on primary health care leading to reduced access, less patient-doctor time and more GP stress but less patient enablement.

The "Freo Street Doctor~~",~~ " is an accredited, street-based mobile health clinic established in 2005 to help meet the needs of marginalised and homeless patients unable or unwilling to access mainstream primary health care~~,~~. It operates ~~in~~ from a number of designated areas within Fremantle and surrounding suburbs in Western Australia. Whilst the target population is mainly marginalised and disadvantaged patients, access to the service is unrestricted with electronic records kept for all attendees. The clinic team consists of general practitioners, nurses, outreach workers, Indigenous health workers and social workers. Our study aims to examine the demographic profile of patients using this street health service compared to mainstream primary care practices, the range and severity of morbidities/chronic diseases across anatomical domains and compares these parameters for Aboriginal and non-Aboriginal patients.

METHOD

Study Setting

The entire patient cohort attending the "Freo Street Doctor" service over the period 1 January 2006 to 31 December 2011 was examined. Patient data was entered by reception, medical and nursing staff into standard practice software and stored centrally at Fremantle Medicare Local offices. Data for the study were ~~using data~~ extracted from ~~electronic~~ the central medical record~~s~~ ~~stored at the Fremantle Medicare Local. Data from the street health patient cohort were~~ and compared with the total patient population ~~a subset of patient data from~~attending a mainstream general practice clinic[24] servicing the same catchment area over the period 1 July to 31 December 2008.

Data Extraction

Data extraction was undertaken by two GPs and two medical students, all with similar training and prior experience in the use and application of the Cumulative Illness Rating Scale (CIRS). The scoring of chronic conditions using the validated CIRS has been described in detail previously[20,25] as has the Severity Index (SI) classification.[24]

Briefly, records were reviewed and 42 conditions were scored according to CIRS guidelines: 0 = no problems, 1 = mild problems, 2 = moderate morbidity, 3 = severe chronic problems, 4 = extremely severe functional impairment. Conditions were categorised into 14 anatomical domains. Maximum scores for each domain were ~~summed~~added to yield a total score ranging from 0 to 56 for each patient. The total score was then divided by the number of domains with morbidities to generate a CIRS score for each patient ranging from 0 to 4. Severity ratings were defined as 0 = none/low, 1 = mild, 2 = moderate and 3/4 = severe.

The street health dataset contained a large number of one-off consultations. Some attendees had no fixed abode with many using drop-in centres as proxy addresses. As far as possible, data extractors took precautions to guard against double counting. There may have been some limited cross over between street and mainstream practices but, in general, patients attending one service tended to continue doing so.

~~Because the study population was considered at higher risk than same age patients attending mainstream practices and clinical information was limited in some instances, we included patients with conditions that appeared to be ongoing (for example, skin infections post lacerations or scabies infestation). We did so to reflect the types of problems presenting to the Street health service and~~

~~the fact that such conditions were often of much greater magnitude in disadvantaged, marginalised populations such as the homeless and drug users.~~

Operational Definition

Our operational definition of multimorbidity was the co-occurrence of conditions across two or more (2+) domains in individual patients.[26] After data extraction was completed, a random sample of 30 patients across the entire age spectrum for both clinics was re-assessed to measure consistency among raters.

Data Analysis

Data analysis was conducted using SPSS 22 (IBM Corporation). All statistical analyses were tested against an alpha level of 0.05 (two-tailed).

Sample characteristics are expressed as means (standard deviation of the mean) for continuous variables and as frequencies (percentages) for categorical variables. Independent samples t-tests and Chi-Square tests were used to examine any demographic differences between the two samples.

The crude prevalence of multimorbidity was calculated as the number of patients with long-term conditions in 2+ morbidity domains as a proportion of the total sample. Given significant differences in age-sex distribution between the two samples, age-sex adjusted prevalence was calculated for the mainstream sample using direct ~~Prevalence measures were adjusted for age and sex~~ standardisation~~ed~~ to the street health cohort. Chi-square tests were used to examine prevalence differences between the two cohorts. Patterns of multimorbidity are expressed as frequencies.

In addition, to examine age of onset of multimorbidity, we modelled the probability of multimorbidity as a function of age. First, a logistic regression analysis was run with the presence of multimorbidity as the dependent variable, and clinic, age, and age squared (given the non-linear relationship between age and multimorbidity) as independent variables (IV). The regression coefficients (β) for each IV were then used to model the probability of multimorbidity as a function of age in each sample.

Multimorbidity severity was examined using the CIRS SI score as well as distribution of patients within each CIRS severity category. ~~SI categories were defined as 0 (none), 1 (mild), 2 (moderate) and 3 or 4 (severe).~~ General linear modelling (GLM) was used to examine differences in

multimorbidity severity between the two samples, controlling for age and gender. We also counted and compared the number of patients with at least one level 3 or 4 score across CIRS domains,[20] as well as the number of domains with a level 3 or 4 score for each patient as additional indicators of disease severity.

Subgroup analysis was conducted to examine the prevalence and severity of multimorbidity in Indigenous and non-Indigenous patients in the street health cohort. There was no data on Indigenous status in the mainstream cohort for comparison.

We also examined the relationship between demographic characteristics and the presence of multimorbidity across 2, 3, and 5 domains using a series of logistic regression analyses.

Inter-rater reliability between data extractors was assessed using Cronbach's alpha.

Ethics

Ethics approval for the study was obtained from The University of Notre Dame Australia Human Research Ethics Committee.

RESULTS

Patient Characteristics

A total of 2587 patients attended the street health service and 4583 attended mainstream practice over the study periods. The age and gender distribution of patients at both clinics are shown in Table 1. The mean age of street health patients was 37.8 years (SD = 18.7) compared with 36.2 (SD = 21.1) for the mainstream practice. There were no significant differences in age between the two cohorts, p=0.055, but a significant difference in gender distribution was observed. The majority of the street health patients were male (57.3%, 1482/2587) while the majority of patients attending mainstream practice were female (60.7%, 2783/4583), p<0.001.

Table 1. Age and Gender Distribution for Study Population

	Fremantle Street Doctor			Mainstream practice (n = 4583)
	Overall (n = 2587)	Aboriginal (n = 766)	Non-Aboriginal (n = 1821)	
Sex, % (n)				
Male	57.3 (1482)	50.3 (385)	60.2 (1097)	39.3 (1800)
Female	42.7 (1105)	49.7 (381)	39.8 (724)	60.7 (2783)
Age, mean (SD) [range]				
Overall	37.8 (18.7) [0 to 103]	32.09 (17.9) [0 to 81]	40.19 (18.5) [0 to 103]	36.18 (21.1) [0 to 98]
Male	39.1 (18.5) [0 to 103]	31.8 (18.1) [1 to 81]	41.6 (17.9) [0 to 103]	35.1 (22.3) [0 to 92]
Female	36.1 (18.7) [0 to 90]	32.3 (17.7) [0 to 75]	38.0 (18.9) [0 to 90]	36.9 (20.3) [0 to 98]
Age Category, % (n)				
< 25	24.2 (626)	36.8 (282)	18.9 (344)	28.9 (1326)
25 to 44	39.5 (1023)	35.8 (274)	41.1 (749)	35.7 (1635)
45 to 64	28.3 (732)	24.4 (187)	29.9 (545)	27.1 (1243)
65 to 74	5.3 (136)	2.3 (18)	6.5 (118)	4.6 (211)
75+	2.7 (70)	0.7 (5)	3.6 (65)	3.7 (168)

Aboriginal patients were 29.6% (766/2587) of the street health sample. On average, Aboriginal patients were significantly younger than non-Aboriginal patients, with 36.8% (282/766) under the age of 25 compared with only 18.9% (344/1821) of non-Aboriginals, p<0.001. The majority of non-Aboriginal patients were male (60.2%, 1097/1821) while there was a more even gender distribution for Aboriginal patients attending the street health service (male 50.3%, 385/766), p<0.001.

Inter-rater Reliability

Inter-rater reliability between data extractors was tested on CIRS scores and number of domains with morbidities for 30 randomly selected patients from each of the two cohorts. For the street health cohort, the intraclass correlation coefficient (ICC) was 0.94 (95% confidence interval 0.89 to 0.97) for number of domains with morbidities and 0.96 (95% CI 0.93 to 0.98) for total CIRS scores indicating high inter-rater reliability. For the mainstream practice sample, the ICC was 0.98 (95% CI 0.97 to 0.99) for number of domains with morbidities and 0.98 (95% CI 0.97 to 0.99) for CIRS scores.

Prevalence of Multimorbidity

~~Overall, the crude prevalence of multimorbidity was lower in the street health sample.~~ Overall, the crude prevalence of multimorbidity was lower in the street health sample. Multimorbidity, based on the presence of conditions affecting 2+ domains, was present in 46.3% (1199/2587, 95% confidence interval 44.4 to 48.3%) of street health patients, compared with 50.1% (2294/4583, 95% CI 48.6 to 51.5%) of the mainstream sample, p=0.003. A total of 28.0% (724/2587) of the street health cohort had multimorbidity in 3+ domains compared with 31.9% (1464/4583) of mainstream patients, p<0.001. Across 5+ domains, 10% (259/2587) of street health patients showed multimorbidity compared with 12.8% (587/4583) of the mainstream sample, p<0.001.

~~However, after adjusting for sex and age differences, the adjusted prevalence of multimorbidity across 2+ domains for the mainstream sample (43.1%, 2000/4583) was significantly lower than in the street health sample (46.3%), p<0.001.~~

Figure 1 shows the crude prevalence of multimorbidity across 2+ domains for both samples across age groups. The prevalence of multimorbidity among young street health patients aged < 45 years (37.7%, 615/1649) was significantly higher than in the mainstream sample (34.3%, 1017/2961), p=0.045. ~~However, m~~Multimorbidity prevalence was significantly lower in the street health sample for patients 45+ years (62.3% [584/938] vs 78.7% [1277/1622], respectively), p<0.001.

~~However, a~~After direct age-sex adjustment of the mainstream prevalence rate, the prevalence of multimorbidity was significantly higher in the street health (46.3%, 1199/2587) than mainstream sample (43.1%, 2000/4583), p=0.011.

Age of onset of multimorbidity was different for the two populations (Figure 2). For street health patients, the probability of multimorbidity peaked between 61 and 67 years, P ($E_{\text{STREET HEALTH}}$)= 0.78, and then decreased. For mainstream patients, the probability of multimorbidity increased with age,

with the greatest probability of multimorbidity observed for individuals aged over 70 years, *P* ($E_{MAINSTREAM}$)= 0.99. Between the ages of 14 and 43, the probability of multimorbidity was higher for street health patients, *P* ($E_{STREET\ HEALTH}$) = 0.26 to 0.71 vs. *P* ($E_{MAINSTREAM}$) = 0.24 to 0.69, suggesting that younger street health patients are particularly vulnerable to multimorbidity. The greatest difference was observed between the ages of 23 and 34, *P* ($E_{STREET\ HEALTH}$) = 0.43 to 0.62 vs. *P* ($E_{MAINSTREAM}$) = 0.33 to 0.52, with street health patients showing a mean 12% greater chance of multimorbidity than mainstream patients in this age group.

Overall for the street health Aboriginal patients, multimorbidity (2+ domains) was present in 50.4% (386/765, 95% confidence interval 46.9 to 53.9%) compared with 44.6% (813/1821, 95% CI 42.4 to 46.9%) in non-Aboriginals, *p=0.0*07. A total of 33.2% of Aboriginal patients (254/766) had 3+ domains affected compared with 25.8% (470/1821) in non-Aboriginals, *p*<0.001, while 13.7% (105/765) had 5+ domains affected compared with 8.5% (154/1821) in non-Aboriginals, *p*<0.001. Stratified by age, the prevalence of multimorbidity (2+) across all age groups was significantly higher among Aboriginal compared with non-Aboriginal patients, *p*<0.001 (Figure 3).

Patterns of Multimorbidity

Table 2 displays the prevalence of the five most common body system domain combinations across single, 1+, 2+, 3+ and 5+ domains for the street health sample with corresponding prevalence rates in mainstream practice for comparison. Table 2 also displays the prevalence of the five most common domain combinations stratified by age.

Table 3 displays the prevalence of the five most common domain combinations across single, 1+, 2+, 3+ and 5+ domains stratified by Indigenous status and age.

Consistent with the CIRS guidelines, patients with conditions that appeared to be ongoing (for example, leg ulcers, non-healing skin infections and lacerations and scabies infestation) were included in the musculoskeletal/integumental domain.

Table 2. Overall and age category breakdown for the 5 most common domains for Street Health cohort

	Domains	Street Health % (*n*)	Mainstream practice % (*n*)[a-d]	Age category (Street health cohort only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 798)	Musculoskeletal	29.8 (238)**	21.8 (231)	24.2 (58)	49.2 (117)	19.7 (47)	5.9 (14)	0.8 (2)
	Psychiatric	20.3 (162)	18.7 (198)	20.4 (33)	53.7 (87)	24.1 (39)	1.9 (3)	0
	Eye, ear, nose and throat	13.7 (109)*	9.7 (103)	62.4 (68)	18.3 (20)	14.7 (16)	0.9 (1)	3.7 (4)
	Respiratory	9.4 (75)	17.8 (188)	38.7 (29)	29.3 (22)	30.7 (23)	1.3 (1)	0
	Genitourinary	6.9 (55)	8.5 (90)	14.5 (8)	69.1 (38)	14.5 (8)	1.8 (1)	0
One or more domains (*n* = 1997)	Psychiatric	46.7 (933)**	34.6 (1161)	8.6 (80)	48.9 (456)	36.5 (341)	4.7 (44)	1.3 (12)
	Musculoskeletal	42.9 (856)	45.2 (1514)	13.1 (112)	44.6 (382)	31.8 (272)	7.1 (61)	3.4 (29)
	Respiratory	35.0 (699)	35.6 (1193)	11.7 (82)	43.2 (302)	38.6 (270)	4.9 (34)	1.6 (11)
	Eye, ear, nose and throat	19.1 (381)*	22.7 (762)	29.4 (112)	29.7 (113)	29.7 (113)	6.3 (24)	5.0 (19)
	Vascular	18.2 (364)**	22.3 (746)	3.3 (12)	17.6 (64)	53.8 (196)	13.5 (49)	11.8 (43)
Two or more domains (*n* = 1199)	Psychiatric + Respiratory	37.1 (445)**	18.8 (432)	7.2 (32)	48.3 (215)	39.1 (174)	4.3 (19)	1.1 (5)
	Psychiatric + Musculoskeletal	32.4 (388)**	22.2 (510)	3.6 (14)	47.2 (183)	41.8 (162)	5.7 (22)	1.8 (7)
	Respiratory + Musculoskeletal	25.6 (307)*	22.4 (515)	5.9 (18)	42.3 (130)	43.3 (133)	6.8 (21)	1.6 (5)
	Vascular + Musculoskeletal	14.6 (175)**	19.4 (445)	2.3 (4)	17.7 (31)	50.9 (89)	15.4 (27)	13.7 (24)
	Hepatic-Pancreatic + Psychiatric	14.3 (172)**	2.8 (64)	1.7 (3)	45.9 (79)	45.9 (79)	5.3 (9)	1.2 (2)
Three or more domains (*n* = 724)	Psychiatric + Respiratory + Musculoskeletal	30.9 (224)**	14.7 (215)	3.6 (8)	42.4 (95)	47.3 (106)	5.8 (13)	0.9 (2)
	Psychiatric + Haematological + Endocrine	14.5 (105)	14.1 (206)	3.8 (4)	37.1 (39)	46.7 (49)	8.6 (9)	3.8 (4)
	Psychiatric + Respiratory + Vascular	14.4 (104)**	8.5 (125)	2.9 (3)	25.0 (26)	60.6 (63)	8.7 (9)	2.9 (3)
	Psychiatric + Musculoskeletal + Vascular	14.2 (103)	13.1 (192)	1.0 (1)	18.4 (19)	60.2 (62)	14.6 (15)	5.8 (6)
	Psychiatric + Respiratory + Lower Gastrointestinal	13.8 (100)**	5.9 (87)	1.0 (1)	46.0 (46)	50.0 (50)	1.0 (1)	2.0 (2)

[a] For 1 domain only, denominator (n = 1058), [b] For 1+ domains, denominator (n = 3352), [c] For 2+ domains, denominator (n = 2294), [d] For 3+ domains, denominator (n = 1772)

* Chi square test significant at .05 level vs mainstream practice

** Chi square test significant at .001 level vs mainstream practice

Table 3. Overall and age category breakdown for the 5 most common domains for Aboriginal Street Health patients

	Domains	Aboriginal % (*n*)	Non-Aboriginal % (*n*) [a-d]	Age category (Aboriginal patients only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 216)	Musculoskeletal	34.3 (74)	28.2 (164)	55.4 (41)	36.5 (27)	8.1 (6)	0	0
	Eye, ear, nose and throat	19.0 (41)*	11.7 (68)	85.4 (35)	12.2 (5)	2.4 (1)	0	0
	Psychiatric	13.0 (28)*	23.0 (134)	25.0 (7)	57.1 (16)	17.9 (5)	0	0
	Respiratory	8.3 (18)	9.8 (57)	55.6 (10)	22.2 (4)	22.2 (4)	0	0
	Lower gastrointestinal	6.0 (13)	5.0 (29)	30.8 (4)	53.8 (7)	15.4 (2)	0	0
One or more domains (*n* = 602)	Musculoskeletal	47.5 (286)*	40.9 (570)	25.9 (74)	40.2 (115)	30.1 (86)	3.1 (9)	0.7 (2)
	Psychiatric	45.5 (274)	47.2 (659)	10.6 (29)	47.8 (131)	37.2 (102)	4.0 (11)	0.4 (1)
	Respiratory	38.7 (233)*	33.4 (466)	16.3 (38)	42.5 (99)	36.9 (86)	3.4 (8)	0.9 (2)
	Eye, ear, nose and throat	24.9 (150)**	16.6 (231)	42.0 (63)	27.3 (41)	24.7 (37)	4.0 (6)	2.0 (3)
	Endocrine	24.4 (147)**	13.3 (186)	7.5 (11)	34.0 (50)	46.9 (69)	8.8 (13)	2.7 (4)
Two or more domains (*n* = 386)	Psychiatric + Respiratory	39.6 (153)	35.9 (292)	9.8 (15)	47.7 (73)	38.6 (59)	3.3 (5)	0.7 (1)
	Psychiatric + Musculoskeletal	35.2 (136)	31.0 (252)	5.1 (7)	46.3 (63)	44.1 (60)	4.4 (6)	0
	Respiratory + Musculoskeletal	31.3 (121)*	22.9 (186)	9.1 (11)	42.1 (51)	43.8 (53)	4.1 (5)	0.8 (1)
	Respiratory + Endocrine	20.2 (78)**	7.7 (63)	5.1 (4)	35.9 (28)	50.0 (39)	7.7 (6)	1.3 (1)
	Psychiatric + Endocrine	19.2 (74)**	10.2 (83)	5.4 (4)	36.5 (27)	47.3 (35)	9.5 (7)	1.4 (1)
Three or more domains (*n* = 254)	Psychiatric + Respiratory + Musculoskeletal	35.8 (91)*	28.3 (133)	5.5 (5)	44.0 (40)	47.3 (43)	3.3 (3)	0
	Psychiatric + Haematological + Endocrine	22.4 (57)**	10.2 (48)	3.5 (2)	40.4 (23)	47.4 (27)	7.0 (4)	1.8 (1)
	Respiratory + Musculoskeletal + Endocrine	18.9 (48)**	7.4 (35)	2.1 (1)	31.3 (15)	60.4 (29)	6.3 (3)	0
	Vascular + Respiratory + Endocrine	18.5 (47)**	6.8 (32)	0	27.7 (13)	63.8 (30)	6.4 (3)	2.1 (1)
	Psychiatric + Vascular + Respiratory	18.1 (46)*	12.3 (58)	2.2 (1)	28.3 (13)	65.2 (30)	2.2 (1)	2.2 (1)

[a] For 1 domain only, denominator (n = 582), [b] For 1+ domains, denominator (n = 1395), [c] For 2+ domains, denominator (n = 813), [d] For 3+ domains, denominator (n = 470)

* Chi square test significant at .05 level vs Non-Aboriginal

** Chi square test significant at .001 level vs Non-Aboriginal

Multimorbidity Severity Index

Overall, GLM analysis revealed a significantly greater severity of disease among the street health cohort. Controlling for age and gender, street health patients (M = 1.4, SD = .91) had significantly higher multimorbidity severity than mainstream patients (M = 1.1, SD = .80), $p<0.001$.

A significantly greater proportion of the street health patients were represented in the moderate (34.1%, 883/2587, 95% confidence interval 32.3 to 35.9%), $p<0.001$, and severe categories (4.9%, 126/2587, 95% CI 4.1 to 5.8%), $p<0.001$, compared with mainstream patients (moderate: 21.0%, 961/4583, 95% CI 19.8 to 22.2%; severe: 1.2%, 53/4583, 95% CI, 0.9 to 1.5%). When multimorbidity severity was stratified by age (Figure 4), a greater proportion of street health patients were again represented in the moderate and severe categories across every age category.

Overall, 24.4% (632/2587) of street health patients compared to 10.1% (463/4583) of mainstream patients had at least one level 3 or level 4 score across domains, $p<0.001$. For patients with multimorbidity, this was 44.2% (530/1199) for street health cohort vs 18.3% (420/2294) of mainstream patients, $p<0.001$.

Figure 5 shows the frequency trends of number of domains with level 3 or 4 scores[20] for patients with multimorbidity across 2+ domains for both cohorts, revealing a more pronounced and earlier onset of increased disease burden in the 25-44 and 45-64 year age group for street health patients but especially Aboriginal patients.

For the street health cohort, Aboriginal patients scored marginally higher on the CIRS Severity Index (M = 1.39, SD = 0.89) compared with non-Aboriginal patients (M = 1.34, SD = 0.91), although this difference was not statistically significant, $p=0.610$.

Factors Associated with Multimorbidity

Logistic regression analyses using the occurrence of multimorbidity across 2+, 3+ and 5+ domains as the criterion variable showed multimorbidity to be significantly associated with male gender, increasing age and Indigenous status (Table 4). Indigenous status was the strongest predictor of multimorbidity in each model. Aboriginal patients had an 87% increase in the likelihood of displaying multimorbidity across 2+ domains compared with non-Aboriginals. Aboriginal patients were also twice as likely to show multimorbidity across 3+ domains and nearly three times more likely to show multimorbidity across 5+ domains.

Table 4. Relation between socio-demographic characteristics and the prevalence of multimorbidity

Characteristic	Odds ratio	95% CI
2+ Domains		
Male*	1.44	1.22 to 1.70
Age *	1.01	1.04 to 1.05
Indigenous*	1.87	1.55 to2.26
3+ Domains		
Male*	1.41	1.17 to 1.70
Age*	1.04	1.04 to 1.05
Indigenous*	2.17	2.17 to 2.66
5+ Domains		
Male*	1.26	0.96 to 1.67
Age*	1.05	1.04 to 1.06
Indigenous*	2.82	2.11 to 3.77

* $p<.001$

DISCUSSION

Research on multimorbidity among street health populations is scarce with little data available on patterns, prevalence or disease severity among particular age or ethnic groups. Existing research has tended to focus on specific areas, such as homelessness and mental health,[27-29] with little attention on the cumulative and synergistic effects of multiple chronic conditions or a broader bio-psychosocial approach to health care needs.[4,30] The prevalence of multimorbidity is higher in deprived as opposed to more affluent areas[3,31] with multiple physical diseases often co-existing among patients with mental illness.[4,31,32]

This is the first study to use 42 conditions affecting anatomical domains to estimate patterns and prevalence of multimorbidity among marginalised and homeless patients attending a designated, primary care-run, street-based outreach service. Like our earlier mainstream practices study,[24] we include an estimation of disease severity to enhance the overall picture of multimorbidity burden in this population.

Key findings from our study include that multimorbidity is significantly associated with male gender, increasing age and Indigenous status with the latter the strongest predictor of multimorbidity irrespective of whether 2+, 3+ or 5+ domains are used as the criterion variable.

Strengths and limitations of the study

The strengths of this study include the large street health cohort size involving the total population seen over a six year period and the fact that we include a disease severity rating for each patient in addition to prevalence and patterns data recorded.

A major difficulty we encountered was enumerating the homeless population mainly because it lacked a common definition.[33] The open access policy to the street health service could have had a diluting effect on the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances. Among street health patients, 22.8% had no multimorbidity compared with 26.9% among mainstream patients.

In addition, whilst the street health population is based on data collected over a six year period, the comparator mainstream practice data was collected over six months.[24]

Prevalence and patterns

~~Whilst~~ Multimorbidity prevalence among the street health cohort was ~~lower~~ significantly higher than the age-sex adjusted prevalence for the mainstream cohort. The age breakdown across 2+ domains ~~shows~~ shows younger patients as much more vulnerable to having multiple chronic conditions with a 12% greater likelihood among 23 - 34 year old patients. This contrasts with findings from our earlier research where prevalence patterns progressively increased from the 25 – 44 year age group to the 45 – 64 and 65 -74 year age groups.[24] The reason for multimorbidity peaking in the 25 - 44 year age group in the street health population could be explained by the premature deaths of these patients or the possibility that those surviving to older age start attending mainstream practices or become institutional residents.

A key finding from our study is the willingness of Aboriginal patients to attend the street health service - 29.6% v. 1.6% to Australian primary care practices[34] – and that Aboriginal patients overall are significantly younger – 36.8% v. 18.9% under 25 years old - than non-Aboriginal patients. Due to a lack of data on Aboriginality amongst the mainstream practice, it was not possible to compare both cohorts. Among the street health population, Aboriginal patients have significantly higher rates of multimorbidity across all age groups and number of domains affected.

The high prevalence of psychiatric morbidity (46.7%) was not unexpected. The three most common domains - psychiatric, musculoskeletal (42.9%) and respiratory (35.0%) - are similar to mainstream except that psychiatry and musculoskeletal are juxtaposed.[24] These three domains remain most

common even when 2+ or 3+ domains are examined and may act to facilitate or accelerate other morbidities resulting in premature ageing or progressive deterioration.

A notable feature of the street population was the high prevalence of chronic skin conditions (leg ulcers, slow to heal infections/lacerations and scabies) reflecting the reality of poor living circumstances and hygiene. Inclusion of these conditions as part of the musculoskeletal/integumental domain is likely to have increased the overall prevalence for this domain. The possibility that early onset of psychiatric illness may in turn contribute to a cascade of homelessness, lack of stable relationships and failure to achieve educational potential should be considered.

Disease severity

Disease severity burden is of particular value in disadvantaged populations because the cumulative and synergistic nature of their multimorbidities impacts on their need for appropriate health services[30] while their socioeconomic circumstances renders their access to such services inequitable. American, [10] Canadian[9] and British[12,13] studies have all found much common ground with housing, mental illness, poor education and smoking common factors throughout. Complex interventions invariably do better when housing is integrated into the solution and the importance of social geography and family supports acknowledged.[7] There is no definitive answer but well integrated support networks built around primary care services would appear a logical way forward.

We found the multimorbidity SI significantly higher for street health patients, more pronounced with 'moderate' and 'severe' morbidity and persisting across all age categories. Given the large numbers in the two population cohorts, the relatively small but significant differences of 13% in the moderately severe and 4% in the severe disease severity index categories translate to a substantial number of patients. The impost in terms of service delivery could therefore be greater than is primarily evident. Taken together with the fact that the presence of multiple severe or moderately severe chronic conditions is not compatible with long-term survival or management in the primary care setting especially amongst a marginalised, street health population, it is likely to impact directly on Emergency Department visits and hospital admissions. ~~Although overall prevalence is lower in~~

After age-sex adjustment, multimorbidity prevalence is significantly higher among ~~-~~the street health cohort. ~~,~~ ~~where~~ Where disease exists, it tends to be of significantly greater severity. ~~This is also~~as reflected ~~in~~ by the more pronounced domain level 3 and level 4 scores~~,~~. This ~~supporting~~ supports

earlier research by Starfield and Kinder[35] that morbidities are not randomly distributed amongst populations. Instead, those with the highest vulnerability to illness have a greater disadvantage because the clustering of morbidities in these sub-populations diminishes their quality of life.[3] Multimorbidity in such circumstances impacts negatively not just on their functioning status[36,37] but also causes increased and poorly co-ordinated use of health services,[5] increased direct and indirect healthcare costs[6] and heightens the risk of premature death.[38,39]

Conclusion

Our study reports on the prevalence, patterns and disease severity of multimorbidity among a marginalised population attending a primary care-led, street health clinic in Western Australia. Overall, the probability of early onset (23-34 years) multimorbidity is higher in the street health cohort compared with mainstream practice but not in patients aged over 45 years with psychiatric, musculoskeletal and respiratory the commonest domains affected. For Aboriginal patients, the prevalence of multimorbidity is higher across all ages but especially if aged < 25 years~~.~~.

Disease severity is significantly higher in the street health population, especially Aboriginal patients, with greater 'moderate' and 'severe' morbidity and persists across all age categories. Attendance patterns for Aboriginal patients suggest they are more likely to engage with street-based, outreach service than mainstream practice. Reasons for this increased engagement warrant further investigation.

Our findings have implications on the design and delivery of health care services to meet the increasing challenge of multimorbidity[4,40] in disadvantaged and Indigenous populations. Traditional ~~Traditional~~approaches to service delivery fail to meet the needs of this population.[12] Such services need more complex interventions but are unlikely to receive appropriate health services expenditure and compare unfavourably with that offered to mainstream patients. A more integrated outreach approach involving better housing, psychiatric, education and social supports would seem logical to address their needs. Longer term prospective studies including an economic analysis component would be helpful.

WHAT THIS PAPER ADDS:

What is already known on this subject

Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect health care costs and generally make poor utilisation of available health services. Mental illness, drug and alcohol abuse are especially common in homeless people. The Inverse Care Law[11] ensures that those in greatest need generally receive the least treatment.

What this study adds

Our study shows multimorbidity amongst street health patients is common, more severe and exists across all anatomical domains with younger patients (23-34 year olds) and Aboriginal patients especially vulnerable. Among the street health population, multimorbidity is significantly associated with male gender, increasing age and Indigenous status. Aboriginal patients comprise 29.6% of the street health cohort which compares favourably with the 1.6% attending mainstream Australian practices and offers hope for greater engagement of basic health services into the future.

ACKNOWLEDGEMENTS

We acknowledge the assistance of the staff at the Freo Street Doctor clinic, Fremantle Medicare Local and the medical practice involved in the study. We acknowledge the assistance of Drs Maeve Kiely and Cam Phan with data acquisition. Research support was received from The Australian Commonwealth Government Primary Health Care Research Evaluation and Development (PHCRED) Strategy Phase 2. The General Practice and Primary Health Care Research Unit is partly funded under the Collaborative Research Network (CRN) Program Grant from the Australian Government Department of Education to the University of Notre Dame Australia. We also acknowledge financial support from J Galvin, W Cunningham, L Ryan and A Neale.

CONFLICT DISCLOSURE

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: TB, DAR, LT and RGM have received research grant funding; DAR has received support from research donations; no other relationships or activities that could appear to have influenced the submitted work.

DATA SHARING STATEMENT

No additional data are available

CONTRIBUTORS

TB and DAR made substantial contributions to the conception and design of the work as well as the acquisition, analysis and interpretation of data for the study.
LT and MB made substantial contributions to the analysis and interpretation of data.
RGM made substantial contributions to the acquisition of data.
TB, DAR and LT were responsible for drafting the manuscript and all authors revised it critically for important intellectual content, final approval of the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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FIGURE LEGENDS

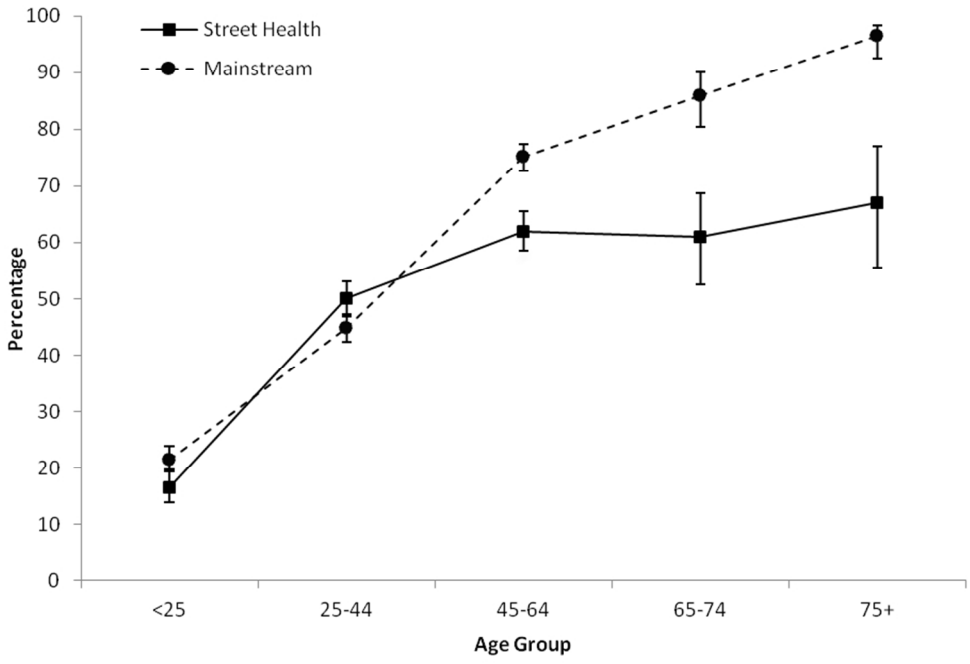
Figure 1. Prevalence of multimorbidity within age groups with 95% confidence intervals

Figure 2. Probability of multimorbidity (2+ domains) as a function of age

Figure 3. Prevalence of multimorbidity in Street Health sample stratified by age and Indigenous status with 95% confidence intervals

Figure 4. Severity Index distribution within age groups

Figure 5. Frequency trends of number of domains with ~~Level~~ level 3 or 4 scores



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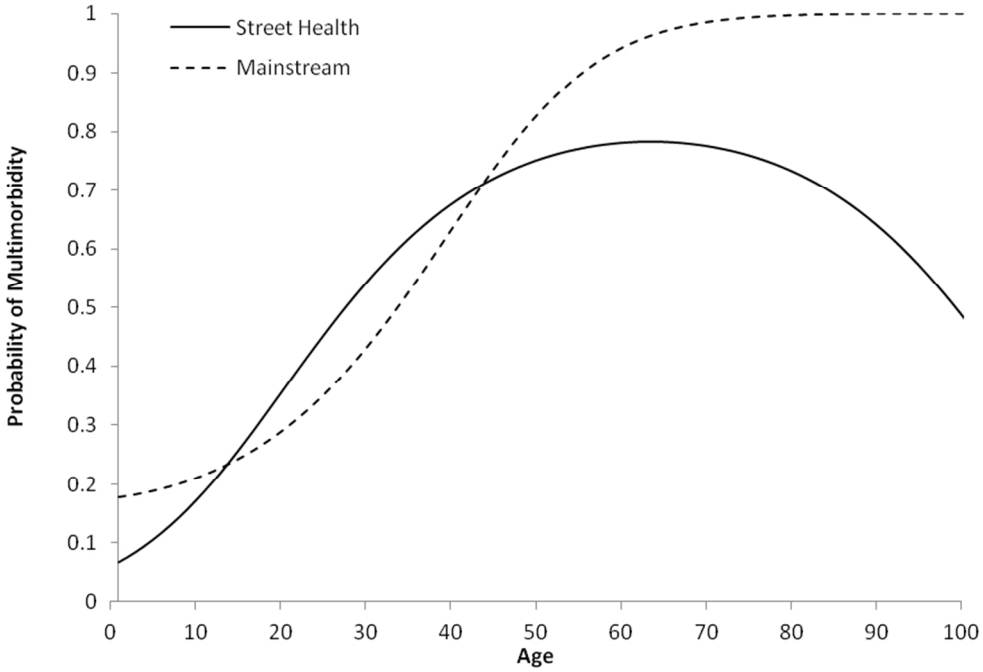

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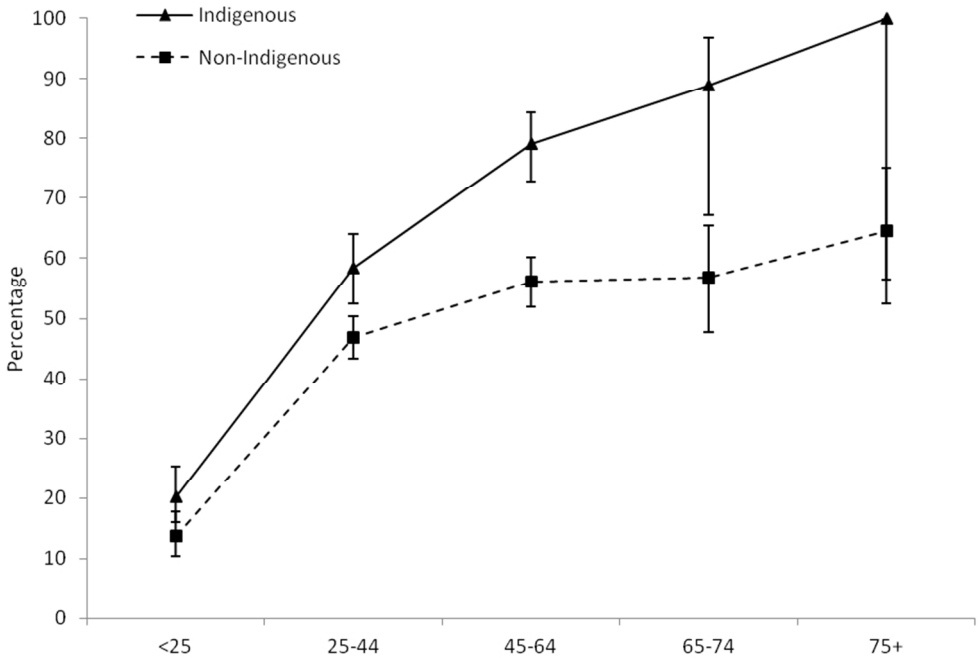

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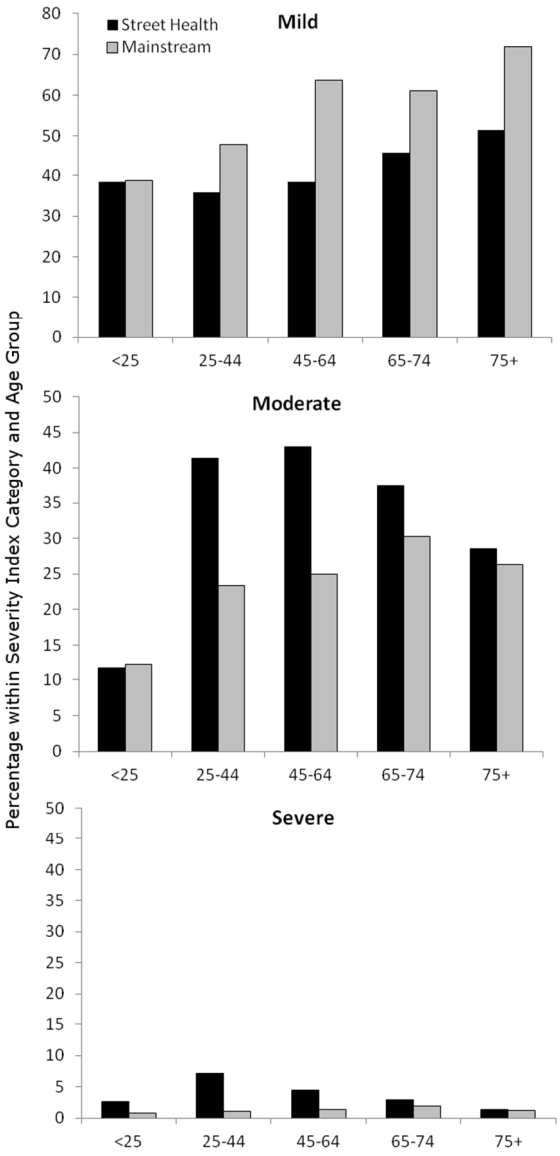

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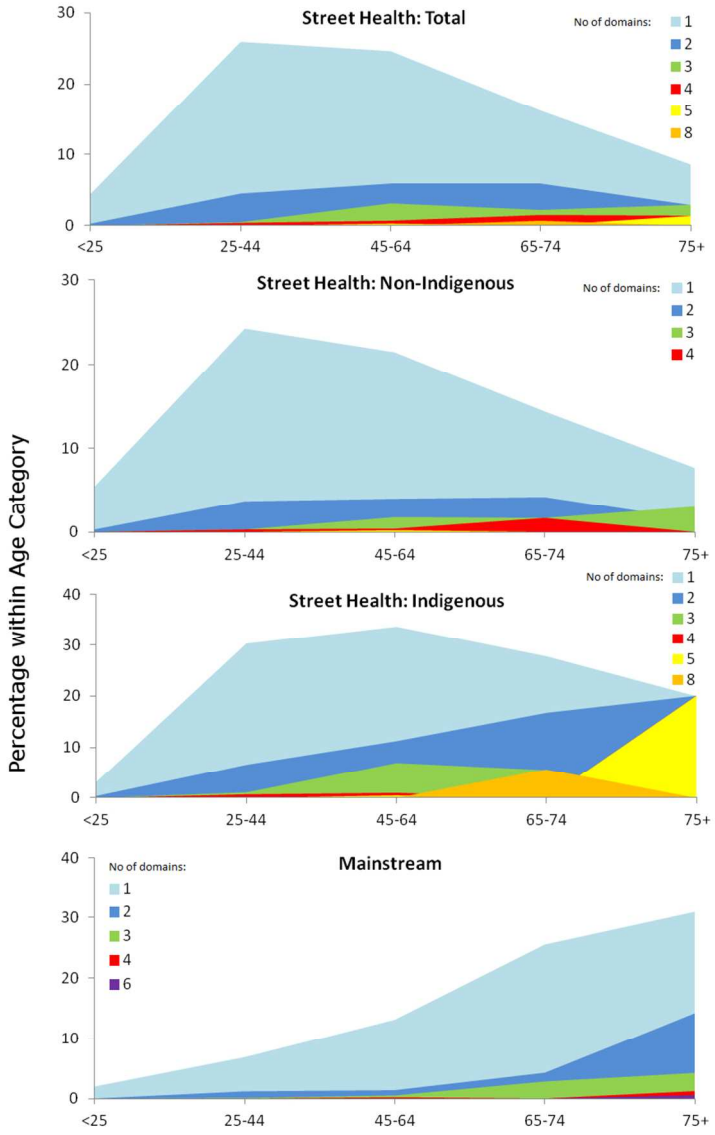

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No (Line No)
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Pg 1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Pg 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Pg 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Pg 5 (50-55)
Methods			
Study design	4	Present key elements of study design early in the paper	Pg 2 (9)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Pg 6 (7-15)
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Pg 6 (7-15)
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Pg 6 (18-48)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pg 7 (5-56) Pg 8 (3-8)
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	Pg 6 (7-15)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pg 6 (51-58) Pg 7 (3-59) Pg 8 (3-8)
		(*b*) Describe any methods used to examine subgroups and interactions	Pg 7 (41-56) Pg 8 (3-5)
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking	N/A

		account of sampling strategy	
		(*e*) Describe any sensitivity analyses	N/A
Results			**Page No (Line No)**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pg 9 (6-7)
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Pg 9 (7-54)
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Pg 10 (14) to Pg 15 (23)
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pgs 10-15
		(*b*) Report category boundaries when continuous variables were categorized	Pg 7 (11-27)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Pg 15 (15-54)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pg 16 (3-20)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pg 16 (24) to Pg 18 (8)
Generalisability	21	Discuss the generalisability (external validity) of the study results	Pg 18 (3) to Pg 19 (11)
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Pg 19 (16-27)

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Multimorbidity in a marginalised, street-health Australian population: A retrospective cohort study

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2014-005461.R2
Article Type:	Research
Date Submitted by the Author:	27-Jun-2014
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Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	General practice / Family practice
Keywords:	PRIMARY CARE, multimorbidity, chronic disease

TITLE: Multimorbidity in a marginalised, street-health Australian population – a retrospective cohort study

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Word count (excluding title page, abstract, references, figures and tables): **4355**

ABSTRACT

Objectives: Demographic and presentation profile of patients using an innovative mobile outreach clinic compared with mainstream practice.

Design: Retrospective cohort study.

Setting: Primary care mobile street health clinic and mainstream practice in Western Australia.

Participants: 2587 street health and 4583 mainstream patients.

Main outcome measures: Prevalence and patterns of chronic diseases in anatomical domains across entire age spectrum of patients and disease severity burden using Cumulative Illness Rating Scale (CIRS).

Results: Multimorbidity (2+ CIRS domains) prevalence was significantly higher in street health cohort (46.3%, 1199/2587) than age-sex adjusted mainstream estimate (43.1%, 2000/4583), *p*=0.011.

Multimorbidity prevalence significantly higher in street health patients <45 years (37.7%, 615/1649) compared to age-sex adjusted mainstream patients (33.0%, 977/2961), *p*=0.003 but significantly lower if 65+ years (62.0%, 114/184 vs 90.7%, 322/355, *p*<0.001).

Controlling for age and gender, mean CIRS Severity Index score for street health (M = 1.4, SD = 0.91) was significantly higher than mainstream patients (M = 1.1, SD = 0.80), *p*<0 .001. Furthermore, 44.2% (530/1199) of street health patients had at least one level 3 or 4 score across domains compared to 18.3% (420/2294) for mainstream patients, *p*<0.001.

Street health population comprised 29.6% (766/2587) Aboriginal patients with 50.4% (386/766) having multimorbidity compared to 44.6% (813/1821) for non-Aboriginals, *p*=0.007. There were no comprehensive data on Indigenous status in mainstream cohort available for comparison.

Musculoskeletal, respiratory and psychiatric domains were most commonly affected with multimorbidity significantly associated with male gender, increasing age and Indigenous status.

Conclusions: Age-sex adjusted multimorbidity prevalence and disease severity higher in street health cohort. Earlier onset (23-34 years) multimorbidity found in street health cohort but prevalence is lower in 65+ years than mainstream patients. Multimorbidity prevalence is higher for Aboriginal patients of all ages.

ARTICLE SUMMARY

Strengths and limitations of the study

- New information on a vulnerable, street-based population accessing an accredited, mobile outreach medical service.
- The large cohort size (n=2587) involving a total street based population seen over a six year period compared with 4583 mainstream patients from similar catchment area.
- Includes a severity rating for each patient in addition to prevalence and patterns of chronic diseases recorded.
- The open access policy to the street health service could have diluted the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances.
- The street health population is based on data collected over a six year period while the comparator mainstream practice data was collected over six months.

KEY WORDS

Multimorbidity, chronic disease, primary healthcare, general practice, severity of illness index

INTRODUCTION

The combination of multiple chronic diseases (multimorbidity) and poor access to primary health care results in serious social, economic and health consequences[1-5] as well as providing considerable challenges for service providers. Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect healthcare costs[6,7] and poor utilisation of primary care health services.[1,8-11] Alcohol and drug related deaths, smoking related diseases, ischemic heart disease and respiratory diseases are especially common.[9] A systematic review[12] found homeless people in Western countries had much greater drug and alcohol dependence compared to age-matched populations while psychotic illnesses and personality disorders were also more common. Canadian homeless and marginally housed people have 32% probability of survival to 75 years among men and 60% among women with housing a key marker for socioeconomic disadvantage.[9] Death rates among 'rough sleepers' in the United Kingdom are 25 times that of the housed population.[13]

Risk factors influencing access to health services include lack of suitable housing,[9,14] mental health problems,[12,15] poor education, unemployment and lack of regular income.[16,17] Social marginalisation impacts negatively on healthcare utilisation including fear of stigmatisation on visiting mainstream practices and waiting rooms.[18] People from Indigenous, non-English speaking and refugee backgrounds often avoid contact with a regular doctor and only seek help when a crisis develops.[19-21] Such individuals have poorer health outcomes[22] exhibiting patterns of chronic, multimorbid disease at a younger age compared to the general population.[23] In Scotland, Mercer[3] found an increased burden of ill-health and multimorbidity in deprived areas resulting in greater demands on primary health care leading to reduced access, less patient-doctor time and more GP stress but less patient enablement.

The "Freo Street Doctor" is an accredited, street-based mobile health clinic established in 2005 to help meet the needs of marginalised and homeless patients unable or unwilling to access mainstream primary health care. It operates from a number of designated areas within Fremantle and surrounding suburbs in Western Australia. Whilst the target population is mainly marginalised and disadvantaged patients, access to the service is unrestricted with electronic records kept for all attendees. The clinic team consists of general practitioners, nurses, outreach workers, Indigenous health workers and social workers. Our study aims to examine the demographic profile of patients using this street health service compared to mainstream primary care practices, the range and

severity of morbidities/chronic diseases across anatomical domains and compares these parameters for Aboriginal and non-Aboriginal patients.

METHOD

Study Setting

The entire patient cohort attending the "Freo Street Doctor" service over the period 1 January 2006 to 31 December 2011 was examined. Patient data was entered by reception, medical and nursing staff into standard practice software and stored centrally at Fremantle Medicare Local offices. Data for the study were extracted from the central medical records and compared with the total patient population attending a mainstream general practice clinic[24] servicing the same catchment area over the period 1 July to 31 December 2008.

Data Extraction

Data extraction was undertaken by two GPs and two medical students, all with similar training and prior experience in the use and application of the Cumulative Illness Rating Scale (CIRS). The scoring of chronic conditions using the validated CIRS has been described in detail previously[20,25] as has the Severity Index (SI) classification.[24]

Briefly, records were reviewed and 42 conditions were scored according to CIRS guidelines: 0 = no problems, 1 = mild problems, 2 = moderate morbidity, 3 = severe chronic problems, 4 = extremely severe functional impairment. Conditions were categorised into 14 anatomical domains. Maximum scores for each domain were added to yield a total score ranging from 0 to 56 for each patient. The total score was then divided by the number of domains with morbidities to generate a CIRS score for each patient ranging from 0 to 4. Severity ratings were defined as 0 = none/low, 1 = mild, 2 = moderate and 3/4 = severe.

For both cohorts conditions within a particular anatomical domain were noted to be present only if the information in the records suggested the condition was ongoing/chronic and then rated according to the CIRS. The street health dataset contained a large number of one-off consultations. Some attendees had no fixed abode with many using drop-in centres as proxy addresses.

As far as possible, data extractors took precautions to guard against double counting. There may have been some limited cross over between street and mainstream practices but, in general, patients attending one service tended to continue doing so.

Operational Definition

Our operational definition of multimorbidity was the co-occurrence of conditions across two or more (2+) domains in individual patients.[26] After data extraction was completed, a random sample of 30 patients across the entire age spectrum for both clinics was re-assessed to measure consistency among raters.

Data Analysis

Data analysis was conducted using SPSS 22 (IBM Corporation). All statistical analyses were tested against an alpha level of 0.05 (two-tailed).

Sample characteristics are expressed as means (standard deviation of the mean) for continuous variables and as frequencies (percentages) for categorical variables. Independent sample t-tests and Chi-Square tests were used to examine any demographic differences between the two samples.

The crude prevalence of multimorbidity was calculated as the number of patients with long-term conditions in 2+ morbidity domains as a proportion of the total sample. Given significant differences in age-sex distribution between the two samples, age-sex adjusted prevalence was calculated for the mainstream sample using direct standardisation to the street health cohort. Chi-square tests were used to examine prevalence differences between the two cohorts. Patterns of multimorbidity are expressed as frequencies.

In addition to examining age of onset of multimorbidity, we modelled the probability of multimorbidity as a function of age. First, a logistic regression analysis was run with the presence of multimorbidity as the dependent variable, and clinic, age, and age squared (given the non-linear relationship between age and multimorbidity) as independent variables (IV). The regression coefficients (β) for each IV were then used to model the probability of multimorbidity as a function of age in each sample.

Multimorbidity severity was examined using the CIRS SI score as well as distribution of patients within each CIRS severity category. General linear modelling (GLM) was used to examine differences in multimorbidity severity between the two samples, controlling for age and gender. We also counted and compared the number of patients with at least one level 3 or 4 score across CIRS domains,[20] as well as the number of domains with a level 3 or 4 score for each patient as additional indicators of disease severity.

Subgroup analysis was conducted to examine the prevalence and severity of multimorbidity in Indigenous and non-Indigenous patients in the street health cohort. There was no data on Indigenous status in the mainstream cohort for comparison.

We also examined the relationship between demographic characteristics and the presence of multimorbidity across 2, 3, and 5 domains using a series of logistic regression analyses.

Inter-rater reliability between data extractors was assessed using Cronbach's alpha.

Ethics

Ethics approval for the study was obtained from The University of Notre Dame Australia Human Research Ethics Committee.

RESULTS

Patient Characteristics

A total of 2587 patients attended the street health service and 4583 attended mainstream practice over the study periods. The age and gender distribution of patients at both clinics are shown in Table 1. The mean age of street health patients was 37.8 years (SD = 18.7) compared with 36.2 (SD = 21.1) for the mainstream practice. There were no significant differences in age between the two cohorts, p=0.055, but a significant difference in gender distribution was observed. The majority of the street health patients were male (57.3%, 1482/2587) while the majority of patients attending mainstream practice were female (60.7%, 2783/4583), p<0.001.

Table 1. Age and Gender Distribution for Study Population

	Fremantle Street Doctor			Mainstream practice
	Overall (n = 2587)	Aboriginal (n = 766)	Non-Aboriginal (n = 1821)	(n = 4583)
Sex, % (n)				
Male	57.3 (1482)	50.3 (385)	60.2 (1097)	39.3 (1800)
Female	42.7 (1105)	49.7 (381)	39.8 (724)	60.7 (2783)
Age, mean (SD) [range]				
Overall	37.8 (18.7) [0 to 103]	32.09 (17.9) [0 to 81]	40.19 (18.5) [0 to 103]	36.18 (21.1) [0 to 98]
Male	39.1 (18.5) [0 to 103]	31.8 (18.1) [1 to 81]	41.6 (17.9) [0 to 103]	35.1 (22.3) [0 to 92]
Female	36.1 (18.7) [0 to 90]	32.3 (17.7) [0 to 75]	38.0 (18.9) [0 to 90]	36.9 (20.3) [0 to 98]
Age Category, % (n)				
< 25	24.2 (626)	36.8 (282)	18.9 (344)	28.9 (1326)
25 to 44	39.5 (1023)	35.8 (274)	41.1 (749)	35.7 (1635)
45 to 64	28.3 (732)	24.4 (187)	29.9 (545)	27.1 (1243)
65 to 74	5.3 (136)	2.3 (18)	6.5 (118)	4.6 (211)
75+	2.7 (70)	0.7 (5)	3.6 (65)	3.7 (168)

Aboriginal patients were 29.6% (766/2587) of the street health sample. On average, Aboriginal patients were significantly younger than non-Aboriginal patients, with 36.8% (282/766) under the age of 25 compared with only 18.9% (344/1821) of non-Aboriginals, p<0.001. The majority of non-Aboriginal patients were male (60.2%, 1097/1821) while there was a more even gender distribution for Aboriginal patients attending the street health service (male 50.3%, 385/766), p<0.001.

Inter-rater Reliability

Inter-rater reliability between data extractors was tested on CIRS scores and number of domains with morbidities for 30 randomly selected patients from each of the two cohorts. For the street health cohort, the intraclass correlation coefficient (ICC) was 0.94 (95% confidence interval 0.89 to 0.97) for number of domains with morbidities and 0.96 (95% CI 0.93 to 0.98) for total CIRS scores indicating high inter-rater reliability. For the mainstream practice sample, the ICC was 0.98 (95% CI 0.97 to 0.99) for number of domains with morbidities and 0.98 (95% CI 0.97 to 0.99) for CIRS scores.

Prevalence of Multimorbidity

Overall, the crude prevalence of multimorbidity was lower in the street health sample. Multimorbidity, based on the presence of conditions affecting 2+ domains, was present in 46.3% (1199/2587, 95% confidence interval (CI) 44.4 to 48.3%) of street health patients, compared with 50.1% (2294/4583, 95% CI 48.6 to 51.5%) of the mainstream sample, p=0.003.

After direct age-sex adjustment of the mainstream prevalence rates, the prevalence of multimorbidity was significantly higher in the street health (46.3%, 1199/2587, 95% CI 44.4 to 48.3%) compared with mainstream sample (43.1%, 2000/4583, 95% CI 42.2 to 45.8%), p=0.011. The prevalence of multimorbidity in 3+ domains was comparable between the street health (28.0%, 724/2587, 95% CI 26.3 to 29.7%) and mainstream samples (29.2%, 1339/4583, 95% CI 27.9 to 30.5%), p=0.269. There was also no significant difference in multimorbidity prevalence across 5+ domains between the street health (10%, 259/2587, 95% CI 8.9 to 11.2%) and mainstream (10.5%, 485/4583, 95% CI 9.7 to 11.5%) samples, p=0.437.

Figure 1 shows prevalence of multimorbidity across 2+ domains for the street health and age-sex adjusted mainstream samples across age groups. The prevalence of multimorbidity among street health patients aged <45 years (37.3%, 615/1649, 95% CI 34.9 to 39.7%) was significantly higher than in the adjusted mainstream sample (33.0%, 977/2961, 95% CI 31.3 to 34.7%), p=0.003. Multimorbidity prevalence was comparable in the 45 to 64 year age group for the street health (62.0%, 454/732, 95% CI 58.4 to 65.5%) and adjusted mainstream (62.5%, 778/1243, 95% CI 59.9 to 66.2%) samples, p=0.825. Multimorbidity prevalence was significantly lower in the street health sample for patients 65+ years (62.0%, 114/184, 95% CI 54.8 to 68.7%) compared to the adjusted mainstream sample (90.7%, 322/355, 95% CI 87.2 to 93.3%), p<0.001.

Age of onset of multimorbidity was different for the two populations (Figure 2). For street health patients, the probability of multimorbidity peaked between 61 and 67 years, P ($E_{\text{STREET HEALTH}}$)= 0.78,

and then decreased. For mainstream patients, the probability of multimorbidity increased with age, with the greatest probability of multimorbidity observed for individuals aged over 70 years, *P* ($E_{MAINSTREAM}$)= 0.99. Between the ages of 14 and 43, the probability of multimorbidity was higher for street health patients, *P* ($E_{\text{STREET HEALTH}}$) range 0.26 to 0.71 vs. *P* ($E_{\text{MAINSTREAM}}$) range 0.24 to 0.69, suggesting that younger street health patients are particularly vulnerable to multimorbidity. The greatest difference was observed between the ages of 23 and 34, *P* ($E_{\text{STREET HEALTH}}$) range 0.43 to 0.62 vs. *P* ($E_{\text{MAINSTREAM}}$) range 0.33 to 0.52, with street health patients showing a mean 12% greater chance of multimorbidity than mainstream patients in this age group.

Overall for the street health Aboriginal patients, multimorbidity (2+ domains) was present in 50.4% (386/765, 95% CI 46.9 to 53.9%) compared with 44.6% (813/1821, 95% CI 42.4 to 46.9%) in non-Aboriginals, p=0.007. A total of 33.2% of Aboriginal patients (254/766, 95% CI 29.9 to 36.6%) had 3+ domains affected compared with 25.8% (470/1821, 95% CI 23.8 to 27.9%) in non-Aboriginals, p<0.001, while 13.7% (105/765, 95% CI 11.5 to 16.3%) had 5+ domains affected compared with 8.5% (154/1821, 95% CI 7.3 to 9.8%) in non-Aboriginals, p<0.001. Stratified by age, the prevalence of multimorbidity (2+) across all age groups was significantly higher among Aboriginal compared with non-Aboriginal patients, p<0.001 (Figure 3).

Patterns of Multimorbidity

Table 2 displays the prevalence of the five most common body system domain combinations across single, 1+, 2+, 3+ and 5+ domains for the street health sample with corresponding prevalence rates in mainstream practice for comparison. Table 2 also displays the prevalence of the five most common domain combinations stratified by age.

Table 3 displays the prevalence of the five most common domain combinations across single, 1+, 2+, 3+ and 5+ domains stratified by Indigenous status and age.

Consistent with the CIRS guidelines, patients with conditions that appeared to be ongoing (for example, chronic ulcers and non-healing skin infections /lacerations) were included in the musculoskeletal/integumental domain.

Table 2. Overall and age category breakdown for the 5 most common domains for Street Health cohort

	Domains	Street Health % (*n*)	Mainstream practice % (*n*)[a-d]	Age category (Street health cohort only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 798)	Musculoskeletal	29.8 (238)**	21.8 (231)	24.2 (58)	49.2 (117)	19.7 (47)	5.9 (14)	0.8 (2)
	Psychiatric	20.3 (162)	18.7 (198)	20.4 (33)	53.7 (87)	24.1 (39)	1.9 (3)	0
	Eye, ear, nose and throat	13.7 (109)*	9.7 (103)	62.4 (68)	18.3 (20)	14.7 (16)	0.9 (1)	3.7 (4)
	Respiratory	9.4 (75)	17.8 (188)	38.7 (29)	29.3 (22)	30.7 (23)	1.3 (1)	0
	Genitourinary	6.9 (55)	8.5 (90)	14.5 (8)	69.1 (38)	14.5 (8)	1.8 (1)	0
One or more domains (*n* = 1997)	Psychiatric	46.7 (933)**	34.6 (1161)	8.6 (80)	48.9 (456)	36.5 (341)	4.7 (44)	1.3 (12)
	Musculoskeletal	42.9 (856)	45.2 (1514)	13.1 (112)	44.6 (382)	31.8 (272)	7.1 (61)	3.4 (29)
	Respiratory	35.0 (699)	35.6 (1193)	11.7 (82)	43.2 (302)	38.6 (270)	4.9 (34)	1.6 (11)
	Eye, ear, nose and throat	19.1 (381)*	22.7 (762)	29.4 (112)	29.7 (113)	29.7 (113)	6.3 (24)	5.0 (19)
	Vascular	18.2 (364)**	22.3 (746)	3.3 (12)	17.6 (64)	53.8 (196)	13.5 (49)	11.8 (43)
Two or more domains (*n* = 1199)	Psychiatric + Respiratory	37.1 (445)**	18.8 (432)	7.2 (32)	48.3 (215)	39.1 (174)	4.3 (19)	1.1 (5)
	Psychiatric + Musculoskeletal	32.4 (388)**	22.2 (510)	3.6 (14)	47.2 (183)	41.8 (162)	5.7 (22)	1.8 (7)
	Respiratory + Musculoskeletal	25.6 (307)*	22.4 (515)	5.9 (18)	42.3 (130)	43.3 (133)	6.8 (21)	1.6 (5)
	Vascular + Musculoskeletal	14.6 (175)**	19.4 (445)	2.3 (4)	17.7 (31)	50.9 (89)	15.4 (27)	13.7 (24)
	Hepatic-Pancreatic + Psychiatric	14.3 (172)**	2.8 (64)	1.7 (3)	45.9 (79)	45.9 (79)	5.3 (9)	1.2 (2)
Three or more domains (*n* = 724)	Psychiatric + Respiratory + Musculoskeletal	30.9 (224)**	14.7 (215)	3.6 (8)	42.4 (95)	47.3 (106)	5.8 (13)	0.9 (2)
	Psychiatric + Haematological + Endocrine	14.5 (105)	14.1 (206)	3.8 (4)	37.1 (39)	46.7 (49)	8.6 (9)	3.8 (4)
	Psychiatric + Respiratory + Vascular	14.4 (104)**	8.5 (125)	2.9 (3)	25.0 (26)	60.6 (63)	8.7 (9)	2.9 (3)
	Psychiatric + Musculoskeletal + Vascular	14.2 (103)	13.1 (192)	1.0 (1)	18.4 (19)	60.2 (62)	14.6 (15)	5.8 (6)
	Psychiatric + Respiratory + Lower Gastrointestinal	13.8 (100)**	5.9 (87)	1.0 (1)	46.0 (46)	50.0 (50)	1.0 (1)	2.0 (2)

[a] For 1 domain only, denominator (n = 1058), [b] For 1+ domains, denominator (n = 3352), [c] For 2+ domains, denominator (n = 2294), [d] For 3+ domains, denominator (n = 1772)

* Chi square test significant at .05 level vs mainstream practice

** Chi square test significant at .001 level vs mainstream practice

Table 3. Overall and age category breakdown for the 5 most common domains for Aboriginal Street Health patients

	Domains	Aboriginal % (*n*)	Non-Aboriginal % (*n*) [a-d]	Age category (Aboriginal patients only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 216)	Musculoskeletal	34.3 (74)	28.2 (164)	55.4 (41)	36.5 (27)	8.1 (6)	0	0
	Eye, ear, nose and throat	19.0 (41)*	11.7 (68)	85.4 (35)	12.2 (5)	2.4 (1)	0	0
	Psychiatric	13.0 (28)*	23.0 (134)	25.0 (7)	57.1 (16)	17.9 (5)	0	0
	Respiratory	8.3 (18)	9.8 (57)	55.6 (10)	22.2 (4)	22.2 (4)	0	0
	Lower gastrointestinal	6.0 (13)	5.0 (29)	30.8 (4)	53.8 (7)	15.4 (2)	0	0
One or more domains (*n* = 602)	Musculoskeletal	47.5 (286)*	40.9 (570)	25.9 (74)	40.2 (115)	30.1 (86)	3.1 (9)	0.7 (2)
	Psychiatric	45.5 (274)	47.2 (659)	10.6 (29)	47.8 (131)	37.2 (102)	4.0 (11)	0.4 (1)
	Respiratory	38.7 (233)*	33.4 (466)	16.3 (38)	42.5 (99)	36.9 (86)	3.4 (8)	0.9 (2)
	Eye, ear, nose and throat	24.9 (150)**	16.6 (231)	42.0 (63)	27.3 (41)	24.7 (37)	4.0 (6)	2.0 (3)
	Endocrine	24.4 (147)**	13.3 (186)	7.5 (11)	34.0 (50)	46.9 (69)	8.8 (13)	2.7 (4)
Two or more domains (*n* = 386)	Psychiatric + Respiratory	39.6 (153)	35.9 (292)	9.8 (15)	47.7 (73)	38.6 (59)	3.3 (5)	0.7 (1)
	Psychiatric + Musculoskeletal	35.2 (136)	31.0 (252)	5.1 (7)	46.3 (63)	44.1 (60)	4.4 (6)	0
	Respiratory + Musculoskeletal	31.3 (121)*	22.9 (186)	9.1 (11)	42.1 (51)	43.8 (53)	4.1 (5)	0.8 (1)
	Respiratory + Endocrine	20.2 (78)**	7.7 (63)	5.1 (4)	35.9 (28)	50.0 (39)	7.7 (6)	1.3 (1)
	Psychiatric + Endocrine	19.2 (74)**	10.2 (83)	5.4 (4)	36.5 (27)	47.3 (35)	9.5 (7)	1.4 (1)
Three or more domains (*n* = 254)	Psychiatric + Respiratory + Musculoskeletal	35.8 (91)*	28.3 (133)	5.5 (5)	44.0 (40)	47.3 (43)	3.3 (3)	0
	Psychiatric + Haematological + Endocrine	22.4 (57)**	10.2 (48)	3.5 (2)	40.4 (23)	47.4 (27)	7.0 (4)	1.8 (1)
	Respiratory + Musculoskeletal + Endocrine	18.9 (48)**	7.4 (35)	2.1 (1)	31.3 (15)	60.4 (29)	6.3 (3)	0
	Vascular + Respiratory + Endocrine	18.5 (47)**	6.8 (32)	0	27.7 (13)	63.8 (30)	6.4 (3)	2.1 (1)
	Psychiatric + Vascular + Respiratory	18.1 (46)*	12.3 (58)	2.2 (1)	28.3 (13)	65.2 (30)	2.2 (1)	2.2 (1)

[a] For 1 domain only, denominator (n = 582), [b] For 1+ domains, denominator (n = 1395), [c] For 2+ domains, denominator (n = 813), [d] For 3+ domains, denominator (n = 470)

* Chi square test significant at .05 level vs Non-Aboriginal

** Chi square test significant at .001 level vs Non-Aboriginal

Multimorbidity Severity Index

Overall, GLM analysis revealed a significantly greater severity of disease among the street health cohort. Controlling for age and gender, street health patients (M = 1.4, SD = .91) had significantly higher multimorbidity severity than mainstream patients (M = 1.1, SD = .80), $p<0.001$.

A significantly greater proportion of the street health patients were represented in the moderate (34.1%, 883/2587, 95% CI 32.3 to 35.9%), $p<0.001$, and severe categories (4.9%, 126/2587, 95% CI 4.1 to 5.8%), $p<0.001$, compared with mainstream patients (moderate: 21.0%, 961/4583, 95% CI 19.8 to 22.2%; severe: 1.2%, 53/4583, 95% CI, 0.9 to 1.5%). When multimorbidity severity was stratified by age (Figure 4), a greater proportion of street health patients were again represented in the moderate and severe categories across every age category.

Overall, 24.4% (632/2587) of street health patients compared to 10.1% (463/4583) of mainstream patients had at least one level 3 or level 4 score across domains, $p<0.001$. For patients with multimorbidity, this was 44.2% (530/1199) for street health cohort vs 18.3% (420/2294) of mainstream patients, $p<0.001$.

Figure 5 shows the frequency trends of number of domains with level 3 or 4 scores[20] for patients with multimorbidity across 2+ domains for both cohorts, revealing a more pronounced and earlier onset of increased disease burden in the 25-44 and 45-64 year age group for street health patients but especially Aboriginal patients.

For the street health cohort, Aboriginal patients scored marginally higher on the CIRS Severity Index (M = 1.39, SD = 0.89) compared with non-Aboriginal patients (M = 1.34, SD = 0.91), although this difference was not statistically significant, $p=0.610$.

Factors Associated with Multimorbidity

Logistic regression analyses using the occurrence of multimorbidity across 2+, 3+ and 5+ domains as the criterion variable showed multimorbidity to be significantly associated with male gender, increasing age and Indigenous status (Table 4). Indigenous status was the strongest predictor of multimorbidity in each model. Aboriginal patients had an 87% increase in the likelihood of displaying multimorbidity across 2+ domains compared with non-Aboriginals. Aboriginal patients were also twice as likely to show multimorbidity across 3+ domains and nearly three times more likely to show multimorbidity across 5+ domains.

Table 4. Relation between socio-demographic characteristics and the prevalence of multimorbidity

Characteristic	Odds ratio	95% CI
2+ Domains		
Male*	1.44	1.22 to 1.70
Age *	1.01	1.04 to 1.05
Indigenous*	1.87	1.55 to2.26
3+ Domains		
Male*	1.41	1.17 to 1.70
Age*	1.04	1.04 to 1.05
Indigenous*	2.17	2.17 to 2.66
5+ Domains		
Male*	1.26	0.96 to 1.67
Age*	1.05	1.04 to 1.06
Indigenous*	2.82	2.11 to 3.77

* $p<.001$

DISCUSSION

Research on multimorbidity among street health populations is scarce with little data available on patterns, prevalence or disease severity among particular age or ethnic groups. Existing research has tended to focus on specific areas, such as homelessness and mental health,[27-29] with little attention on the cumulative and synergistic effects of multiple chronic conditions or a broader bio-psychosocial approach to health care needs.[4,30] The prevalence of multimorbidity is higher in deprived as opposed to more affluent areas[3,31] with multiple physical diseases often co-existing among patients with mental illness.[4,31,32]

This is the first study to use 42 conditions affecting anatomical domains to estimate patterns and prevalence of multimorbidity among marginalised and homeless patients attending a designated, primary care-run, street-based outreach service. Like our earlier mainstream practices study,[24] we include an estimation of disease severity to enhance the overall picture of multimorbidity burden in this population.

Key findings from our study include that multimorbidity is significantly associated with male gender, increasing age and Indigenous status with the latter the strongest predictor of multimorbidity irrespective of whether 2+, 3+ or 5+ domains are used as the criterion variable.

Strengths and limitations of the study

The strengths of this study include the large street health cohort size involving the total population seen over a six year period and the fact that we include a disease severity rating for each patient in addition to prevalence and patterns data recorded.

A major difficulty we encountered was enumerating the homeless population mainly because it lacked a common definition.[33] The open access policy to the street health service could have had a diluting effect on the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances. Among street health patients, 22.8% had no multimorbidity compared with 26.9% among mainstream patients.

Our method of estimation of multimorbidty relies on the accrual of formal diagnoses of conditions which in turn partly relies on regular attendance with care providers. Hence, the transient nature of the street health cohort may have impact on the estimation of multimorbidity compared to the more stable mainstream cohort.

In addition, whilst the street health population is based on data collected over a six year period, the comparator mainstream practice data was collected over six months.[24]

Chronic skin ulcers and slow to heal lacerations/infections were prominent in street cohort compared to mainstream reflecting the reality of their poor living circumstances and hygiene. Inclusion of these conditions as part of the musculoskeletal/integumental domain was based on their recurrent, chronic presentations in this population and is likely to have increased the overall prevalence of this domain. It was not possible to estimate proportion of musculoskeletal/integumental domain that related to chronic skin problems.

Prevalence and patterns

Multimorbidity prevalence among the street health cohort was significantly higher than the age-sex adjusted prevalence for the mainstream cohort. The age breakdown across 2+ domains shows younger patients as much more vulnerable to having multiple chronic conditions with a 12% greater likelihood among 23 - 34 year old patients. This contrasts with findings from our earlier research where prevalence patterns progressively increased from the 25 – 44 year age group to the 45 – 64 and 65 -74 year age groups[24] and results in the flatter trajectory of the S-shaped distribution curve as seen in Figure 1. The reason for multimorbidity peaking in the 25 - 44 year age group in the street health population could be explained by the premature deaths of these patients or the possibility

that those surviving to older age start attending mainstream practices or become institutional residents.

A key finding from our study is the willingness of Aboriginal patients to attend the street health service - 29.6% v. 1.6% to Australian primary care practices[34] – and that Aboriginal patients overall are significantly younger – 36.8% v. 18.9% under 25 years old - than non-Aboriginal patients. Due to a lack of data on Indigenous status amongst the mainstream practice, it was not possible to compare both cohorts. Among the street health population, Aboriginal patients have significantly higher rates of multimorbidity across all age groups and number of domains affected.

The high prevalence of psychiatric morbidity (46.7%) was not unexpected. The three most common domains - psychiatric, musculoskeletal (42.9%) and respiratory (35.0%) - are similar to mainstream except that psychiatry and musculoskeletal are juxtaposed.[24] These three domains remain most common even when 2+ or 3+ domains are examined and may act to facilitate or accelerate other morbidities resulting in premature ageing or progressive deterioration.

The possibility that early onset of psychiatric illness may in turn contribute to a cascade of homelessness, lack of stable relationships and failure to achieve educational potential should be considered.

Disease severity

Disease severity burden is of particular value in disadvantaged populations because the cumulative and synergistic nature of their multimorbidities impacts on their need for appropriate health services[30] while their socioeconomic circumstances renders their access to such services inequitable. American,[10] Canadian[9] and British[12,13] studies have all found much common ground with housing, mental illness, poor education and smoking common factors throughout. Complex interventions invariably do better when housing is integrated into the solution and the importance of social geography and family supports acknowledged.[7] There is no definitive answer but well integrated support networks built around primary care services would appear a logical way forward.

We found the multimorbidity SI significantly higher for street health patients, more pronounced with 'moderate' and 'severe' morbidity and persisting across all age categories. Given the large numbers in the two population cohorts, the relatively small but significant differences of 13% in the

moderately severe and 4% in the severe disease severity index categories translate to a substantial number of patients. The impost in terms of service delivery could therefore be greater than is primarily evident. Taken together with the fact that the presence of multiple severe or moderately severe chronic conditions is not compatible with long-term survival or management in the primary care setting especially amongst a marginalised, street health population, it is likely to impact directly on Emergency Department visits and hospital admissions.

After age-sex adjustment, multimorbidity prevalence is significantly higher among the street health cohort. Where disease exists, it tends to be of significantly greater severity as reflected by the more pronounced domain level 3 and level 4 scores. This supports earlier research by Starfield and Kinder[35] that morbidities are not randomly distributed amongst populations. Instead, those with the highest vulnerability to illness have a greater disadvantage because the clustering of morbidities in these sub-populations diminishes their quality of life.[3] Multimorbidity in such circumstances impacts negatively not just on their functioning status[36,37] but also causes increased and poorly co-ordinated use of health services,[5] increased direct and indirect healthcare costs[6] and heightens the risk of premature death.[38,39]

Conclusion

Our study reports on the prevalence, patterns and disease severity of multimorbidity among a marginalised population attending a primary care-led, street health clinic in Western Australia. Overall, the probability of early onset (23-34 years) multimorbidity is higher in the street health cohort compared with mainstream practice but not in patients aged over 45 years with psychiatric, musculoskeletal and respiratory the commonest domains affected. For Aboriginal patients, the prevalence of multimorbidity is higher across all ages but especially if aged < 25 years.

Disease severity is significantly higher in the street health population, especially Aboriginal patients, with greater 'moderate' and 'severe' morbidity and persists across all age categories. Attendance patterns for Aboriginal patients suggest they are more likely to engage with street-based, outreach service than mainstream practice. Reasons for this increased engagement warrant further investigation.

Our findings have implications on the design and delivery of health care services to meet the increasing challenge of multimorbidity[4,40] in disadvantaged and Indigenous populations. Traditional approaches to service delivery fail to meet the needs of this population.[12] Such services need more complex interventions but are unlikely to receive appropriate health services

expenditure and compare unfavourably with that offered to mainstream patients. A more integrated outreach approach involving better housing, psychiatric, education and social supports would seem logical to address their needs. Longer term prospective studies including an economic analysis component would be helpful.

WHAT THIS PAPER ADDS:

What is already known on this subject

Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect health care costs and generally make poor utilisation of available health services. Mental illness, drug and alcohol abuse are especially common in homeless people. The Inverse Care Law[11] ensures that those in greatest need generally receive the least treatment.

What this study adds

Our study shows multimorbidity amongst street health patients is common, more severe and exists across all anatomical domains with younger patients (23-34 year olds) and Aboriginal patients especially vulnerable. Among the street health population, multimorbidity is significantly associated with male gender, increasing age and Indigenous status. Aboriginal patients comprise 29.6% of the street health cohort which compares favourably with the 1.6% attending mainstream Australian practices and offers hope for greater engagement of basic health services into the future.

ACKNOWLEDGEMENTS

We acknowledge the assistance of the staff at the Freo Street Doctor clinic, Fremantle Medicare Local and the medical practice involved in the study. We acknowledge the assistance of Drs Maeve Kiely and Cam Phan with data acquisition. Research support was received from The Australian Commonwealth Government Primary Health Care Research Evaluation and Development (PHCRED) Strategy Phase 2. The General Practice and Primary Health Care Research Unit is partly funded under the Collaborative Research Network (CRN) Program Grant from the Australian Government Department of Education to the University of Notre Dame Australia. We also acknowledge financial support from J Galvin, W Cunningham, L Ryan and A Neale.

CONFLICT DISCLOSURE

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: TB, DAR, LT and RGM have received research grant funding; DAR has received support from research donations; no other relationships or activities that could appear to have influenced the submitted work.

DATA SHARING STATEMENT

No additional data are available

CONTRIBUTORS

TB and DAR made substantial contributions to the conception and design of the work as well as the acquisition, analysis and interpretation of data for the study.

LT and MB made substantial contributions to the analysis and interpretation of data.

RGM made substantial contributions to the acquisition of data.

TB, DAR and LT were responsible for drafting the manuscript and all authors revised it critically for important intellectual content, final approval of the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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FIGURE LEGENDS

Figure 1. Prevalence of multimorbidity within age groups with 95% confidence intervals

Figure 2. Probability of multimorbidity (2+ domains) as a function of age

Figure 3. Prevalence of multimorbidity in Street Health sample stratified by age and Indigenous status with 95% confidence intervals

Figure 4. Severity Index distribution within age groups

Figure 5. Frequency trends of number of domains with level 3 or 4 scores

TITLE: Multimorbidity in a marginalised, street-health Australian population – a retrospective cohort study

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Word count (excluding title page, abstract, references, figures and tables): ~~3,8294~~4355

ABSTRACT

Objectives: Demographic and presentation profile of patients using an innovative mobile outreach clinic compared with mainstream practice.

Design: Retrospective cohort study.

Setting: Primary care mobile street health clinic and mainstream practice in Western Australia.

Participants: 2587 street health and 4583 mainstream patients.

Main outcome measures: Prevalence and patterns of chronic diseases in anatomical domains across entire age spectrum of patients and disease severity burden using Cumulative Illness Rating Scale (CIRS).

Results: ~~Lower m~~Multimorbidity (2+ CIRS domains) prevalence was significantly higher in street health cohort (46.3%, 1199/2587) than ~~mainstream (50.1%, 2294/4583), *p*=0.003 when comparing crude estimates but significantly higher when comparing with direct~~ age-sex adjusted ~~-~~mainstream estimate (43.1%, 2000/4583), *p*=0.011.

~~Higher multimorbidity~~ Multimorbidity prevalence significantly higher in street health patients <45 years (37.7%, 615/1649) compared to age-sex adjusted mainstream patients (33.0%, 977/2961), *p*=0.003 ~~(34.3%, 1017/2961), p=0.045~~ but significantly lower if ~~45~~65+ years (62.0%, 114/184 ~~62.3%, 584/938~~ vs 90.7%, 322/355~~78.7%, 1277/1622~~, *p*<0.001~~)~~).

~~Street health patients showed significantly greater disease severity.~~ Controlling for age and gender, mean CIRS Severity Index score for street health (M = 1.4, SD = 0.91) was significantly higher than mainstream patients (M = 1.1, SD = 0.80), *p*<0 .001. Furthermore, 44.2% (530/1199) of street health patients had at least one level 3 or 4 score across domains compared to 18.3% (420/2294) ~~of~~ for mainstream patients, *p*<0.001.

~~Aboriginal patients were 29.6% (766/2587) of s~~Street health population comprised 29.6% (766/2587) Aboriginal patients with 50.4% (386/766) having multimorbidity ~~vs~~ compared to 44.6% (813/1821) for non-Aboriginals, *p*=0.007. There were no ~~No~~ comprehensive data on Indigenous status in mainstream cohort available for comparison.

Musculoskeletal, respiratory and psychiatric domains were most commonly affected with multimorbidity significantly associated with male gender, increasing age and Indigenous status.

Conclusions: Age-sex adjusted multimorbidity- prevalence -and disease severity -higher in street health cohort-. ~~Early~~ Earlier onset (23-34 years) multimorbidity ~~is higher~~ found in street health cohort but prevalence is lower in ~~45~~65+ years than mainstream patients. Multimorbidity prevalence is higher for Aboriginal patients of all ages.

ARTICLE SUMMARY

Strengths and limitations of the study

- New information on a vulnerable, street-based population accessing an accredited, mobile outreach medical service.
- The large cohort size (n=2587) involving a total street based population seen over a six year period compared with 4583 mainstream patients from similar catchment area.
- Includes a severity rating for each patient in addition to prevalence and patterns of chronic diseases recorded.
- The open access policy to the street health service could have diluted the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances.
- The street health population is based on data collected over a six year period while the comparator mainstream practice data was collected over six months.

KEY WORDS

Multimorbidity, chronic disease, primary healthcare, general practice, severity of illness index

INTRODUCTION

The combination of multiple chronic diseases (multimorbidity) and poor access to primary health care results in serious social, economic and health consequences[1-5] as well as providing considerable challenges for service providers. Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect healthcare costs[6,7] and poor utilisation of primary care health services.[1,8-11] Alcohol and drug related deaths, smoking related diseases, ischemic heart disease and respiratory diseases are especially common.[9] A systematic review[12] found homeless people in Western countries had much greater drug and alcohol dependence compared to age-matched populations while psychotic illnesses and personality disorders were also more common. Canadian homeless and marginally housed people have 32% probability of survival to 75 years among men and 60% among women with housing a key marker for socioeconomic disadvantage.[9] Death rates among 'rough sleepers' in the United Kingdom are 25 times that of the housed population.[13]

Risk factors influencing access to health services include lack of suitable housing,[9,14] mental health problems,[12,15] poor education, unemployment and lack of regular income.[16,17] Social marginalisation impacts negatively on healthcare utilisation including fear of stigmatisation on visiting mainstream practices and waiting rooms.[18] People from Indigenous, non-English speaking and refugee backgrounds often avoid contact with a regular doctor and only seek help when a crisis develops.[19-21] Such individuals have poorer health outcomes[22] exhibiting patterns of chronic, multimorbid disease at a younger age compared to the general population.[23] In Scotland, Mercer[3] found an increased burden of ill-health and multimorbidity in deprived areas resulting in greater demands on primary health care leading to reduced access, less patient-doctor time and more GP stress but less patient enablement.

The "Freo Street Doctor" is an accredited, street-based mobile health clinic established in 2005 to help meet the needs of marginalised and homeless patients unable or unwilling to access mainstream primary health care. It operates from a number of designated areas within Fremantle and surrounding suburbs in Western Australia. Whilst the target population is mainly marginalised and disadvantaged patients, access to the service is unrestricted with electronic records kept for all attendees. The clinic team consists of general practitioners, nurses, outreach workers, Indigenous health workers and social workers. Our study aims to examine the demographic profile of patients using this street health service compared to mainstream primary care practices, the range and

severity of morbidities/chronic diseases across anatomical domains and compares these parameters for Aboriginal and non-Aboriginal patients.

METHOD

Study Setting

The entire patient cohort attending the "Freo Street Doctor" service over the period 1 January 2006 to 31 December 2011 was examined. Patient data was entered by reception, medical and nursing staff into standard practice software and stored centrally at Fremantle Medicare Local offices. Data for the study were extracted from the central medical records and compared with the total patient population attending a mainstream general practice clinic[24] servicing the same catchment area over the period 1 July to 31 December 2008.

Data Extraction

Data extraction was undertaken by two GPs and two medical students, all with similar training and prior experience in the use and application of the Cumulative Illness Rating Scale (CIRS). The scoring of chronic conditions using the validated CIRS has been described in detail previously[20,25] as has the Severity Index (SI) classification.[24]

Briefly, records were reviewed and 42 conditions were scored according to CIRS guidelines: 0 = no problems, 1 = mild problems, 2 = moderate morbidity, 3 = severe chronic problems, 4 = extremely severe functional impairment. Conditions were categorised into 14 anatomical domains. Maximum scores for each domain were added to yield a total score ranging from 0 to 56 for each patient. The total score was then divided by the number of domains with morbidities to generate a CIRS score for each patient ranging from 0 to 4. Severity ratings were defined as 0 = none/low, 1 = mild, 2 = moderate and 3/4 = severe.

For both cohorts conditions within a particular anatomical domain were noted to be present only if the information in the records suggested the condition was ongoing/chronic and then rated according to the CIRS.

The street health dataset contained a large number of one-off consultations. Some attendees had no fixed abode with many using drop-in centres as proxy addresses.

As far as possible, data extractors took precautions to guard against double counting. There may have been some limited cross over between street and mainstream practices but, in general, patients attending one service tended to continue doing so.

Operational Definition

Our operational definition of multimorbidity was the co-occurrence of conditions across two or more (2+) domains in individual patients.[26] After data extraction was completed, a random sample of 30 patients across the entire age spectrum for both clinics was re-assessed to measure consistency among raters.

Data Analysis

Data analysis was conducted using SPSS 22 (IBM Corporation). All statistical analyses were tested against an alpha level of 0.05 (two-tailed).

Sample characteristics are expressed as means (standard deviation of the mean) for continuous variables and as frequencies (percentages) for categorical variables. Independent sample~~s~~ t-tests and Chi-Square tests were used to examine any demographic differences between the two samples.

The crude prevalence of multimorbidity was calculated as the number of patients with long-term conditions in 2+ morbidity domains as a proportion of the total sample. Given significant differences in age-sex distribution between the two samples, age-sex adjusted prevalence was calculated for the mainstream sample using direct standardisation to the street health cohort. Chi-square tests were used to examine prevalence differences between the two cohorts. Patterns of multimorbidity are expressed as frequencies.

In addition~~,~~ to ~~examine~~ examining age of onset of multimorbidity, we modelled the probability of multimorbidity as a function of age. First, a logistic regression analysis was run with the presence of multimorbidity as the dependent variable, and clinic, age, and age squared (given the non-linear relationship between age and multimorbidity) as independent variables (IV). The regression coefficients (β) for each IV were then used to model the probability of multimorbidity as a function of age in each sample.

Multimorbidity severity was examined using the CIRS SI score as well as distribution of patients within each CIRS severity category. General linear modelling (GLM) was used to examine differences in multimorbidity severity between the two samples, controlling for age and gender. We also counted and compared the number of patients with at least one level 3 or 4 score across CIRS domains,[20] as well as the number of domains with a level 3 or 4 score for each patient as additional indicators of disease severity.

Subgroup analysis was conducted to examine the prevalence and severity of multimorbidity in Indigenous and non-Indigenous patients in the street health cohort. There was no data on Indigenous status in the mainstream cohort for comparison.

We also examined the relationship between demographic characteristics and the presence of multimorbidity across 2, 3, and 5 domains using a series of logistic regression analyses.

Inter-rater reliability between data extractors was assessed using Cronbach's alpha.

Ethics

Ethics approval for the study was obtained from The University of Notre Dame Australia Human Research Ethics Committee.

RESULTS

Patient Characteristics

A total of 2587 patients attended the street health service and 4583 attended mainstream practice over the study periods. The age and gender distribution of patients at both clinics are shown in Table 1. The mean age of street health patients was 37.8 years (SD = 18.7) compared with 36.2 (SD = 21.1) for the mainstream practice. There were no significant differences in age between the two cohorts, p=0.055, but a significant difference in gender distribution was observed. The majority of the street health patients were male (57.3%, 1482/2587) while the majority of patients attending mainstream practice were female (60.7%, 2783/4583), p<0.001.

Table 1. Age and Gender Distribution for Study Population

	Fremantle Street Doctor			Mainstream practice (n = 4583)
	Overall (n = 2587)	Aboriginal (n = 766)	Non-Aboriginal (n = 1821)	
Sex, % (n)				
Male	57.3 (1482)	50.3 (385)	60.2 (1097)	39.3 (1800)
Female	42.7 (1105)	49.7 (381)	39.8 (724)	60.7 (2783)
Age, mean (SD) [range]				
Overall	37.8 (18.7) [0 to 103]	32.09 (17.9) [0 to 81]	40.19 (18.5) [0 to 103]	36.18 (21.1) [0 to 98]
Male	39.1 (18.5) [0 to 103]	31.8 (18.1) [1 to 81]	41.6 (17.9) [0 to 103]	35.1 (22.3) [0 to 92]
Female	36.1 (18.7) [0 to 90]	32.3 (17.7) [0 to 75]	38.0 (18.9) [0 to 90]	36.9 (20.3) [0 to 98]
Age Category, % (n)				
< 25	24.2 (626)	36.8 (282)	18.9 (344)	28.9 (1326)
25 to 44	39.5 (1023)	35.8 (274)	41.1 (749)	35.7 (1635)
45 to 64	28.3 (732)	24.4 (187)	29.9 (545)	27.1 (1243)
65 to 74	5.3 (136)	2.3 (18)	6.5 (118)	4.6 (211)
75+	2.7 (70)	0.7 (5)	3.6 (65)	3.7 (168)

Aboriginal patients were 29.6% (766/2587) of the street health sample. On average, Aboriginal patients were significantly younger than non-Aboriginal patients, with 36.8% (282/766) under the age of 25 compared with only 18.9% (344/1821) of non-Aboriginals, p<0.001. The majority of non-Aboriginal patients were male (60.2%, 1097/1821) while there was a more even gender distribution for Aboriginal patients attending the street health service (male 50.3%, 385/766), p<0.001.

Inter-rater Reliability

Inter-rater reliability between data extractors was tested on CIRS scores and number of domains with morbidities for 30 randomly selected patients from each of the two cohorts. For the street health cohort, the intraclass correlation coefficient (ICC) was 0.94 (95% confidence interval 0.89 to 0.97) for number of domains with morbidities and 0.96 (95% CI 0.93 to 0.98) for total CIRS scores indicating high inter-rater reliability. For the mainstream practice sample, the ICC was 0.98 (95% CI 0.97 to 0.99) for number of domains with morbidities and 0.98 (95% CI 0.97 to 0.99) for CIRS scores.

Prevalence of Multimorbidity

Overall, the crude prevalence of multimorbidity was lower in the street health sample. Multimorbidity, based on the presence of conditions affecting 2+ domains, was present in 46.3% (1199/2587, 95% confidence interval (CI) 44.4 to 48.3%) of street health patients, compared with 50.1% (2294/4583, 95% CI 48.6 to 51.5%) of the mainstream sample, p=0.003.

~~A total of 28.0% (724/2587) of the street health cohort had multimorbidity in 3+ domains compared with 31.9% (1464/4583) of mainstream patients, p<0.001. Across 5+ domains, 10% (259/2587) of street health patients showed multimorbidity compared with 12.8% (587/4583) of the mainstream sample, p<0.001.~~

After direct age-sex adjustment of the mainstream prevalence rates, the prevalence of multimorbidity was significantly higher in the street health (46.3%, 1199/2587, 95% ~~confidence interval~~ CI 44.4 to 48.3%) compared with mainstream sample (43.1%, 2000/4583, 95% CI 42.2 to 45.8%), p=0.011. The prevalence of multimorbidity in 3+ domains was comparable between the street health (28.0%, 724/2587, 95% CI 26.3 to 29.7%) and mainstream samples (29.2%, 1339/4583, 95% CI 27.9 to 30.5%), p=0.269. There was also no significant difference in multimorbidity prevalence across 5+ domains between the street health (10%, 259/2587, 95% CI 8.9 to 11.2%) and mainstream (10.5%, 485/4583, 95% CI 9.7 to 11.5%) samples, p=0.437.

~~After direct age-sex adjustment of the mainstream prevalence rate, the prevalence of multimorbidity was significantly higher in the street health (46.3%, 1199/2587) compared with mainstream sample (43.1%, 2000/4583), p=0.011~~

Figure 1 ~~shows~~ shows ~~the crude~~ prevalence of multimorbidity across 2+ domains for the street health and age-sex adjusted mainstream ~~both~~ samples across age groups. The prevalence of multimorbidity among ~~young~~ street health patients aged <45 years (37.3%, 615/1649, 95% CI 34.9 to 39.7%~~37.7%, 615/1649~~) was significantly higher than in the adjusted mainstream sample (33.0%, 977/2961, 95% CI 31.3 to 34.7%~~34.3%, 1017/2961~~), p=~~0.045~~0.003. Multimorbidity prevalence was

comparable in the 45 to 64 year age group for the street health (62.0%, 454/732, 95% CI 58.4 to 65.5%) and adjusted mainstream (62.5%, 778/1243, 95% CI 59.9 to 66.2%) samples, *p*=0.825. Multimorbidity prevalence was significantly lower in the street health sample for patients ~~45~~65+ years (62.~~3~~0%, ~~584/938~~114/184, 95% CI 54.8 to 68.7%) compared to ~~the adjusted~~the adjusted mainstream sample ~~vs(78.7% [1277/1622], r~~90.7%, 322/355, 95% CI 87.2 to 93.3%~~espectively~~), *p*<0.001.

~~After direct age-sex adjustment of the mainstream prevalence rate, the prevalence of multimorbidity was significantly higher in the street health (46.3%, 1199/2587) than mainstream sample (43.1%, 2000/4583), *p*=0.011.~~

Age of onset of multimorbidity was different for the two populations (Figure 2). For street health patients, the probability of multimorbidity peaked between 61 and 67 years, P ($E_{\text{STREET HEALTH}}$)= 0.78, and then decreased. For mainstream patients, the probability of multimorbidity increased with age, with the greatest probability of multimorbidity observed for individuals aged over 70 years, P ($E_{MAINSTREAM}$)= 0.99. Between the ages of 14 and 43, the probability of multimorbidity was higher for street health patients, P ($E_{\text{STREET HEALTH}}$) ~~=~~ range 0.26 to 0.71 vs. P ($E_{\text{MAINSTREAM}}$) ~~=~~ range 0.24 to 0.69, suggesting that younger street health patients are particularly vulnerable to multimorbidity. The greatest difference was observed between the ages of 23 and 34, P ($E_{\text{STREET HEALTH}}$) ~~=~~ range 0.43 to 0.62 vs. P ($E_{\text{MAINSTREAM}}$) ~~=~~ range 0.33 to 0.52, with street health patients showing a mean 12% greater chance of multimorbidity than mainstream patients in this age group.

Overall for the street health Aboriginal patients, multimorbidity (2+ domains) was present in 50.4% (386/765, 95% ~~confidence interval~~CI 46.9 to 53.9%) compared with 44.6% (813/1821, 95% CI 42.4 to 46.9%) in non-Aboriginals, *p*=0.007. A total of 33.2% of Aboriginal patients (254/766, 95% CI 29.9 to 36.6%) had 3+ domains affected compared with 25.8% (470/1821, 95% CI 23.8 to 27.9%) in non-Aboriginals, *p*<0.001, while 13.7% (105/765, 95% CI 11.5 to 16.3%) had 5+ domains affected compared with 8.5% (154/1821, 95% CI 7.3 to 9.8%) in non-Aboriginals, *p*<0.001. Stratified by age, the prevalence of multimorbidity (2+) across all age groups was significantly higher among Aboriginal compared with non-Aboriginal patients, *p*<0.001 (Figure 3).

Patterns of Multimorbidity

Table 2 displays the prevalence of the five most common body system domain combinations across single, 1+, 2+, 3+ and 5+ domains for the street health sample with corresponding prevalence rates

in mainstream practice for comparison. Table 2 also displays the prevalence of the five most common domain combinations stratified by age.

Table 3 displays the prevalence of the five most common domain combinations across single, 1+, 2+, 3+ and 5+ domains stratified by Indigenous status and age.

Consistent with the CIRS guidelines, patients with conditions that appeared to be ongoing (for example, chronic ~~leg~~ ulcers and~~,~~ non-healing skin infections ~~and~~ /lacerations ~~and scabies infestation~~) were included in the musculoskeletal/integumental domain.

Table 2. Overall and age category breakdown for the 5 most common domains for Street Health cohort

	Domains	Street Health % (*n*)	Mainstream practice % (*n*)[a-d]	Age category (Street health cohort only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 798)	Musculoskeletal	29.8 (238)**	21.8 (231)	24.2 (58)	49.2 (117)	19.7 (47)	5.9 (14)	0.8 (2)
	Psychiatric	20.3 (162)	18.7 (198)	20.4 (33)	53.7 (87)	24.1 (39)	1.9 (3)	0
	Eye, ear, nose and throat	13.7 (109)*	9.7 (103)	62.4 (68)	18.3 (20)	14.7 (16)	0.9 (1)	3.7 (4)
	Respiratory	9.4 (75)	17.8 (188)	38.7 (29)	29.3 (22)	30.7 (23)	1.3 (1)	0
	Genitourinary	6.9 (55)	8.5 (90)	14.5 (8)	69.1 (38)	14.5 (8)	1.8 (1)	0
One or more domains (*n* = 1997)	Psychiatric	46.7 (933)**	34.6 (1161)	8.6 (80)	48.9 (456)	36.5 (341)	4.7 (44)	1.3 (12)
	Musculoskeletal	42.9 (856)	45.2 (1514)	13.1 (112)	44.6 (382)	31.8 (272)	7.1 (61)	3.4 (29)
	Respiratory	35.0 (699)	35.6 (1193)	11.7 (82)	43.2 (302)	38.6 (270)	4.9 (34)	1.6 (11)
	Eye, ear, nose and throat	19.1 (381)*	22.7 (762)	29.4 (112)	29.7 (113)	29.7 (113)	6.3 (24)	5.0 (19)
	Vascular	18.2 (364)**	22.3 (746)	3.3 (12)	17.6 (64)	53.8 (196)	13.5 (49)	11.8 (43)
Two or more domains (*n* = 1199)	Psychiatric + Respiratory	37.1 (445)**	18.8 (432)	7.2 (32)	48.3 (215)	39.1 (174)	4.3 (19)	1.1 (5)
	Psychiatric + Musculoskeletal	32.4 (388)**	22.2 (510)	3.6 (14)	47.2 (183)	41.8 (162)	5.7 (22)	1.8 (7)
	Respiratory + Musculoskeletal	25.6 (307)*	22.4 (515)	5.9 (18)	42.3 (130)	43.3 (133)	6.8 (21)	1.6 (5)
	Vascular + Musculoskeletal	14.6 (175)**	19.4 (445)	2.3 (4)	17.7 (31)	50.9 (89)	15.4 (27)	13.7 (24)
	Hepatic-Pancreatic + Psychiatric	14.3 (172)**	2.8 (64)	1.7 (3)	45.9 (79)	45.9 (79)	5.3 (9)	1.2 (2)
Three or more domains (*n* = 724)	Psychiatric + Respiratory + Musculoskeletal	30.9 (224)**	14.7 (215)	3.6 (8)	42.4 (95)	47.3 (106)	5.8 (13)	0.9 (2)
	Psychiatric + Haematological + Endocrine	14.5 (105)	14.1 (206)	3.8 (4)	37.1 (39)	46.7 (49)	8.6 (9)	3.8 (4)
	Psychiatric + Respiratory + Vascular	14.4 (104)**	8.5 (125)	2.9 (3)	25.0 (26)	60.6 (63)	8.7 (9)	2.9 (3)
	Psychiatric + Musculoskeletal + Vascular	14.2 (103)	13.1 (192)	1.0 (1)	18.4 (19)	60.2 (62)	14.6 (15)	5.8 (6)
	Psychiatric + Respiratory + Lower Gastrointestinal	13.8 (100)**	5.9 (87)	1.0 (1)	46.0 (46)	50.0 (50)	1.0 (1)	2.0 (2)

[a] For 1 domain only, denominator (n = 1058), [b] For 1+ domains, denominator (n = 3352), [c] For 2+ domains, denominator (n = 2294), [d] For 3+ domains, denominator (n = 1772)

* Chi square test significant at .05 level vs mainstream practice

** Chi square test significant at .001 level vs mainstream practice

Table 3. Overall and age category breakdown for the 5 most common domains for Aboriginal Street Health patients

	Domains	Aboriginal % (*n*)	Non-Aboriginal % (*n*) [a-d]	Age category (Aboriginal patients only)				
				< 25	25 to 44	45 to 64	65 to 74	75+
One domain only (*n* = 216)	Musculoskeletal	34.3 (74)	28.2 (164)	55.4 (41)	36.5 (27)	8.1 (6)	0	0
	Eye, ear, nose and throat	19.0 (41)*	11.7 (68)	85.4 (35)	12.2 (5)	2.4 (1)	0	0
	Psychiatric	13.0 (28)*	23.0 (134)	25.0 (7)	57.1 (16)	17.9 (5)	0	0
	Respiratory	8.3 (18)	9.8 (57)	55.6 (10)	22.2 (4)	22.2 (4)	0	0
	Lower gastrointestinal	6.0 (13)	5.0 (29)	30.8 (4)	53.8 (7)	15.4 (2)	0	0
One or more domains (*n* = 602)	Musculoskeletal	47.5 (286)*	40.9 (570)	25.9 (74)	40.2 (115)	30.1 (86)	3.1 (9)	0.7 (2)
	Psychiatric	45.5 (274)	47.2 (659)	10.6 (29)	47.8 (131)	37.2 (102)	4.0 (11)	0.4 (1)
	Respiratory	38.7 (233)*	33.4 (466)	16.3 (38)	42.5 (99)	36.9 (86)	3.4 (8)	0.9 (2)
	Eye, ear, nose and throat	24.9 (150)**	16.6 (231)	42.0 (63)	27.3 (41)	24.7 (37)	4.0 (6)	2.0 (3)
	Endocrine	24.4 (147)**	13.3 (186)	7.5 (11)	34.0 (50)	46.9 (69)	8.8 (13)	2.7 (4)
Two or more domains (*n* = 386)	Psychiatric + Respiratory	39.6 (153)	35.9 (292)	9.8 (15)	47.7 (73)	38.6 (59)	3.3 (5)	0.7 (1)
	Psychiatric + Musculoskeletal	35.2 (136)	31.0 (252)	5.1 (7)	46.3 (63)	44.1 (60)	4.4 (6)	0
	Respiratory + Musculoskeletal	31.3 (121)*	22.9 (186)	9.1 (11)	42.1 (51)	43.8 (53)	4.1 (5)	0.8 (1)
	Respiratory + Endocrine	20.2 (78)**	7.7 (63)	5.1 (4)	35.9 (28)	50.0 (39)	7.7 (6)	1.3 (1)
	Psychiatric + Endocrine	19.2 (74)**	10.2 (83)	5.4 (4)	36.5 (27)	47.3 (35)	9.5 (7)	1.4 (1)
Three or more domains (*n* = 254)	Psychiatric + Respiratory + Musculoskeletal	35.8 (91)*	28.3 (133)	5.5 (5)	44.0 (40)	47.3 (43)	3.3 (3)	0
	Psychiatric + Haematological + Endocrine	22.4 (57)**	10.2 (48)	3.5 (2)	40.4 (23)	47.4 (27)	7.0 (4)	1.8 (1)
	Respiratory + Musculoskeletal + Endocrine	18.9 (48)**	7.4 (35)	2.1 (1)	31.3 (15)	60.4 (29)	6.3 (3)	0
	Vascular + Respiratory + Endocrine	18.5 (47)**	6.8 (32)	0	27.7 (13)	63.8 (30)	6.4 (3)	2.1 (1)
	Psychiatric + Vascular + Respiratory	18.1 (46)*	12.3 (58)	2.2 (1)	28.3 (13)	65.2 (30)	2.2 (1)	2.2 (1)

[a] For 1 domain only, denominator (n = 582), [b] For 1+ domains, denominator (n = 1395), [c] For 2+ domains, denominator (n = 813), [d] For 3+ domains, denominator (n = 470)

* Chi square test significant at .05 level vs Non-Aboriginal

** Chi square test significant at .001 level vs Non-Aboriginal

Multimorbidity Severity Index

Overall, GLM analysis revealed a significantly greater severity of disease among the street health cohort. Controlling for age and gender, street health patients (M = 1.4, SD = .91) had significantly higher multimorbidity severity than mainstream patients (M = 1.1, SD = .80), $p<0.001$.

A significantly greater proportion of the street health patients were represented in the moderate (34.1%, 883/2587, 95% ~~confidence interval~~CI 32.3 to 35.9%), $p<0.001$, and severe categories (4.9%, 126/2587, 95% CI 4.1 to 5.8%), $p<0.001$, compared with mainstream patients (moderate: 21.0%, 961/4583, 95% CI 19.8 to 22.2%; severe: 1.2%, 53/4583, 95% CI, 0.9 to 1.5%). When multimorbidity severity was stratified by age (Figure 4), a greater proportion of street health patients were again represented in the moderate and severe categories across every age category.

Overall, 24.4% (632/2587) of street health patients compared to 10.1% (463/4583) of mainstream patients had at least one level 3 or level 4 score across domains, $p<0.001$. For patients with multimorbidity, this was 44.2% (530/1199) for street health cohort vs 18.3% (420/2294) of mainstream patients, $p<0.001$.

Figure 5 shows the frequency trends of number of domains with level 3 or 4 scores[20] for patients with multimorbidity across 2+ domains for both cohorts, revealing a more pronounced and earlier onset of increased disease burden in the 25-44 and 45-64 year age group for street health patients but especially Aboriginal patients.

For the street health cohort, Aboriginal patients scored marginally higher on the CIRS Severity Index (M = 1.39, SD = 0.89) compared with non-Aboriginal patients (M = 1.34, SD = 0.91), although this difference was not statistically significant, $p=0.610$.

Factors Associated with Multimorbidity

Logistic regression analyses using the occurrence of multimorbidity across 2+, 3+ and 5+ domains as the criterion variable showed multimorbidity to be significantly associated with male gender, increasing age and Indigenous status (Table 4). Indigenous status was the strongest predictor of multimorbidity in each model. Aboriginal patients had an 87% increase in the likelihood of displaying multimorbidity across 2+ domains compared with non-Aboriginals. Aboriginal patients were also twice as likely to show multimorbidity across 3+ domains and nearly three times more likely to show multimorbidity across 5+ domains.

Table 4. Relation between socio-demographic characteristics and the prevalence of multimorbidity

Characteristic	Odds ratio	95% CI
2+ Domains		
Male*	1.44	1.22 to 1.70
Age *	1.01	1.04 to 1.05
Indigenous*	1.87	1.55 to2.26
3+ Domains		
Male*	1.41	1.17 to 1.70
Age*	1.04	1.04 to 1.05
Indigenous*	2.17	2.17 to 2.66
5+ Domains		
Male*	1.26	0.96 to 1.67
Age*	1.05	1.04 to 1.06
Indigenous*	2.82	2.11 to 3.77

* $p<.001$

DISCUSSION

Research on multimorbidity among street health populations is scarce with little data available on patterns, prevalence or disease severity among particular age or ethnic groups. Existing research has tended to focus on specific areas, such as homelessness and mental health,[27-29] with little attention on the cumulative and synergistic effects of multiple chronic conditions or a broader bio-psychosocial approach to health care needs.[4,30] The prevalence of multimorbidity is higher in deprived as opposed to more affluent areas[3,31] with multiple physical diseases often co-existing among patients with mental illness.[4,31,32]

This is the first study to use 42 conditions affecting anatomical domains to estimate patterns and prevalence of multimorbidity among marginalised and homeless patients attending a designated, primary care-run, street-based outreach service. Like our earlier mainstream practices study,[24] we include an estimation of disease severity to enhance the overall picture of multimorbidity burden in this population.

Key findings from our study include that multimorbidity is significantly associated with male gender, increasing age and Indigenous status with the latter the strongest predictor of multimorbidity irrespective of whether 2+, 3+ or 5+ domains are used as the criterion variable.

Strengths and limitations of the study

The strengths of this study include the large street health cohort size involving the total population seen over a six year period and the fact that we include a disease severity rating for each patient in addition to prevalence and patterns data recorded.

A major difficulty we encountered was enumerating the homeless population mainly because it lacked a common definition.[33] The open access policy to the street health service could have had a diluting effect on the proportion of more traditional users of the service because of one-off opportunistic and convenience attendances. Among street health patients, 22.8% had no multimorbidity compared with 26.9% among mainstream patients.

Our method of estimation of multimorbidty relies on the accrual of formal diagnoses of conditions which in turn partly relies on regular attendance with care providers. Hence, the transient nature of the street health cohort may have impact on the estimation of multimorbidity compared to the more stable mainstream cohort.

In addition, whilst the street health population is based on data collected over a six year period, the comparator mainstream practice data was collected over six months.[24]

Chronic skin ulcers and slow to heal lacerations/infections were prominent in street cohort compared to mainstream reflecting the reality of their poor living circumstances and hygiene. Inclusion of these conditions as part of the musculoskeletal/integumental domain was based on their recurrent, chronic presentations in this population and is likely to have increased the overall prevalence of this domain. It was not possible to estimate proportion of musculoskeletal/integumental domain that related to chronic skin problems.

Prevalence and patterns

Multimorbidity prevalence among the street health cohort was significantly higher than the age-sex adjusted prevalence for the mainstream cohort. The age breakdown across 2+ domains shows younger patients as much more vulnerable to having multiple chronic conditions with a 12% greater likelihood among 23 - 34 year old patients. This contrasts with findings from our earlier research where prevalence patterns progressively increased from the 25 – 44 year age group to the 45 – 64 and 65 -74 year age groups [24] and results in the flatter trajectory of the S-shaped distribution curve as seen in Figure 1. The reason for multimorbidity peaking in the 25 - 44 year age group in the street health population could be explained by the premature deaths of these patients or the

possibility that those surviving to older age start attending mainstream practices or become institutional residents.

A key finding from our study is the willingness of Aboriginal patients to attend the street health service - 29.6% v. 1.6% to Australian primary care practices[34] – and that Aboriginal patients overall are significantly younger – 36.8% v. 18.9% under 25 years old - than non-Aboriginal patients. Due to a lack of data on ~~Aboriginality~~ Indigenous status amongst the mainstream practice, it was not possible to compare both cohorts. Among the street health population, Aboriginal patients have significantly higher rates of multimorbidity across all age groups and number of domains affected.

The high prevalence of psychiatric morbidity (46.7%) was not unexpected. The three most common domains - psychiatric, musculoskeletal (42.9%) and respiratory (35.0%) - are similar to mainstream except that psychiatry and musculoskeletal are juxtaposed.[24] These three domains remain most common even when 2+ or 3+ domains are examined and may act to facilitate or accelerate other morbidities resulting in premature ageing or progressive deterioration.

~~A notable feature of the street population was the high prevalence of chronic skin conditions (leg ulcers, slow to heal infections/lacerations and scabies) reflecting the reality of poor living circumstances and hygiene. Inclusion of these conditions as part of the musculoskeletal/integumental domain is likely to have increased the overall prevalence for this domain.~~ The possibility that early onset of psychiatric illness may in turn contribute to a cascade of homelessness, lack of stable relationships and failure to achieve educational potential should be considered.

Disease severity

Disease severity burden is of particular value in disadvantaged populations because the cumulative and synergistic nature of their multimorbidities impacts on their need for appropriate health services[30] while their socioeconomic circumstances renders their access to such services inequitable. American,[10] Canadian[9] and British[12,13] studies have all found much common ground with housing, mental illness, poor education and smoking common factors throughout. Complex interventions invariably do better when housing is integrated into the solution and the importance of social geography and family supports acknowledged.[7] There is no definitive answer but well integrated support networks built around primary care services would appear a logical way forward.

We found the multimorbidity SI significantly higher for street health patients, more pronounced with 'moderate' and 'severe' morbidity and persisting across all age categories. Given the large numbers in the two population cohorts, the relatively small but significant differences of 13% in the moderately severe and 4% in the severe disease severity index categories translate to a substantial number of patients. The impost in terms of service delivery could therefore be greater than is primarily evident. Taken together with the fact that the presence of multiple severe or moderately severe chronic conditions is not compatible with long-term survival or management in the primary care setting especially amongst a marginalised, street health population, it is likely to impact directly on Emergency Department visits and hospital admissions.

After age-sex adjustment, multimorbidity prevalence is significantly higher among the street health cohort. Where disease exists, it tends to be of significantly greater severity as reflected by the more pronounced domain level 3 and level 4 scores. This supports earlier research by Starfield and Kinder[35] that morbidities are not randomly distributed amongst populations. Instead, those with the highest vulnerability to illness have a greater disadvantage because the clustering of morbidities in these sub-populations diminishes their quality of life.[3] Multimorbidity in such circumstances impacts negatively not just on their functioning status[36,37] but also causes increased and poorly co-ordinated use of health services,[5] increased direct and indirect healthcare costs[6] and heightens the risk of premature death.[38,39]

Conclusion

Our study reports on the prevalence, patterns and disease severity of multimorbidity among a marginalised population attending a primary care-led, street health clinic in Western Australia. Overall, the probability of early onset (23-34 years) multimorbidity is higher in the street health cohort compared with mainstream practice but not in patients aged over 45 years with psychiatric, musculoskeletal and respiratory the commonest domains affected. For Aboriginal patients, the prevalence of multimorbidity is higher across all ages but especially if aged < 25 years.

Disease severity is significantly higher in the street health population, especially Aboriginal patients, with greater 'moderate' and 'severe' morbidity and persists across all age categories. Attendance patterns for Aboriginal patients suggest they are more likely to engage with street-based, outreach service than mainstream practice. Reasons for this increased engagement warrant further investigation.

Our findings have implications on the design and delivery of health care services to meet the increasing challenge of multimorbidity[4,40] in disadvantaged and Indigenous populations. Traditional approaches to service delivery fail to meet the needs of this population.[12] Such services need more complex interventions but are unlikely to receive appropriate health services expenditure and compare unfavourably with that offered to mainstream patients. A more integrated outreach approach involving better housing, psychiatric, education and social supports would seem logical to address their needs. Longer term prospective studies including an economic analysis component would be helpful.

WHAT THIS PAPER ADDS:

What is already known on this subject

Marginalised and homeless people have more chronic diseases, high mortality rates, high direct and indirect health care costs and generally make poor utilisation of available health services. Mental illness, drug and alcohol abuse are especially common in homeless people. The Inverse Care Law[11] ensures that those in greatest need generally receive the least treatment.

What this study adds

Our study shows multimorbidity amongst street health patients is common, more severe and exists across all anatomical domains with younger patients (23-34 year olds) and Aboriginal patients especially vulnerable. Among the street health population, multimorbidity is significantly associated with male gender, increasing age and Indigenous status. Aboriginal patients comprise 29.6% of the street health cohort which compares favourably with the 1.6% attending mainstream Australian practices and offers hope for greater engagement of basic health services into the future.

ACKNOWLEDGEMENTS

We acknowledge the assistance of the staff at the Freo Street Doctor clinic, Fremantle Medicare Local and the medical practice involved in the study. We acknowledge the assistance of Drs Maeve Kiely and Cam Phan with data acquisition. Research support was received from The Australian Commonwealth Government Primary Health Care Research Evaluation and Development (PHCRED) Strategy Phase 2. The General Practice and Primary Health Care Research Unit is partly funded under the Collaborative Research Network (CRN) Program Grant from the Australian Government Department of Education to the University of Notre Dame Australia. We also acknowledge financial support from J Galvin, W Cunningham, L Ryan and A Neale.

CONFLICT DISCLOSURE

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: TB, DAR, LT and RGM have received research grant funding; DAR has received support from research donations; no other relationships or activities that could appear to have influenced the submitted work.

DATA SHARING STATEMENT

No additional data are available

CONTRIBUTORS

TB and DAR made substantial contributions to the conception and design of the work as well as the acquisition, analysis and interpretation of data for the study.

LT and MB made substantial contributions to the analysis and interpretation of data.

RGM made substantial contributions to the acquisition of data.

TB, DAR and LT were responsible for drafting the manuscript and all authors revised it critically for important intellectual content, final approval of the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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FIGURE LEGENDS

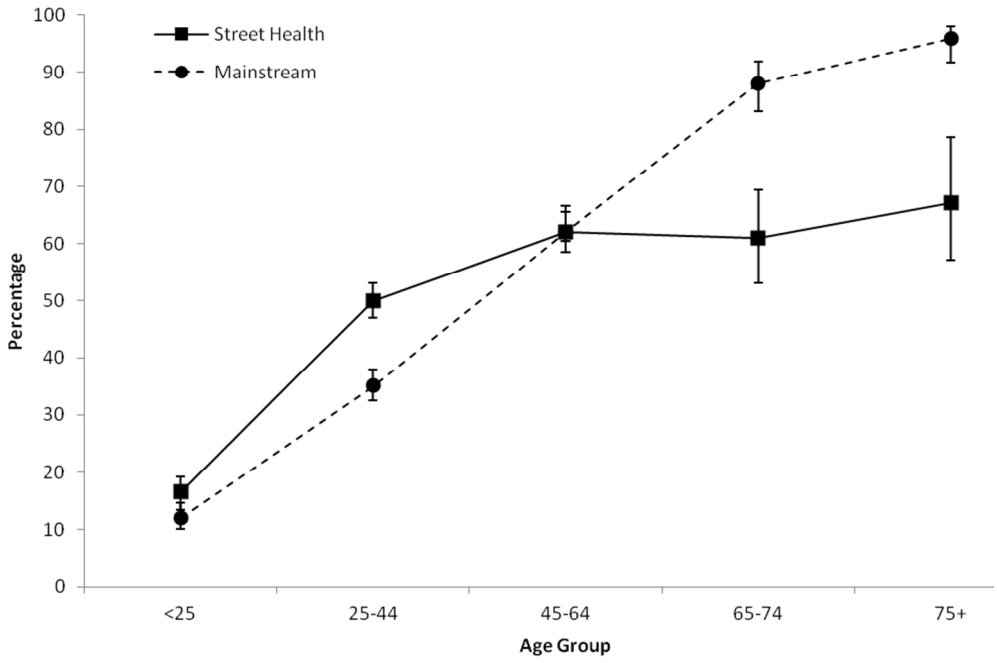
Figure 1. Prevalence of multimorbidity within age groups with 95% confidence intervals

Figure 2. Probability of multimorbidity (2+ domains) as a function of age

Figure 3. Prevalence of multimorbidity in Street Health sample stratified by age and Indigenous status with 95% confidence intervals

Figure 4. Severity Index distribution within age groups

Figure 5. Frequency trends of number of domains with level 3 or 4 scores



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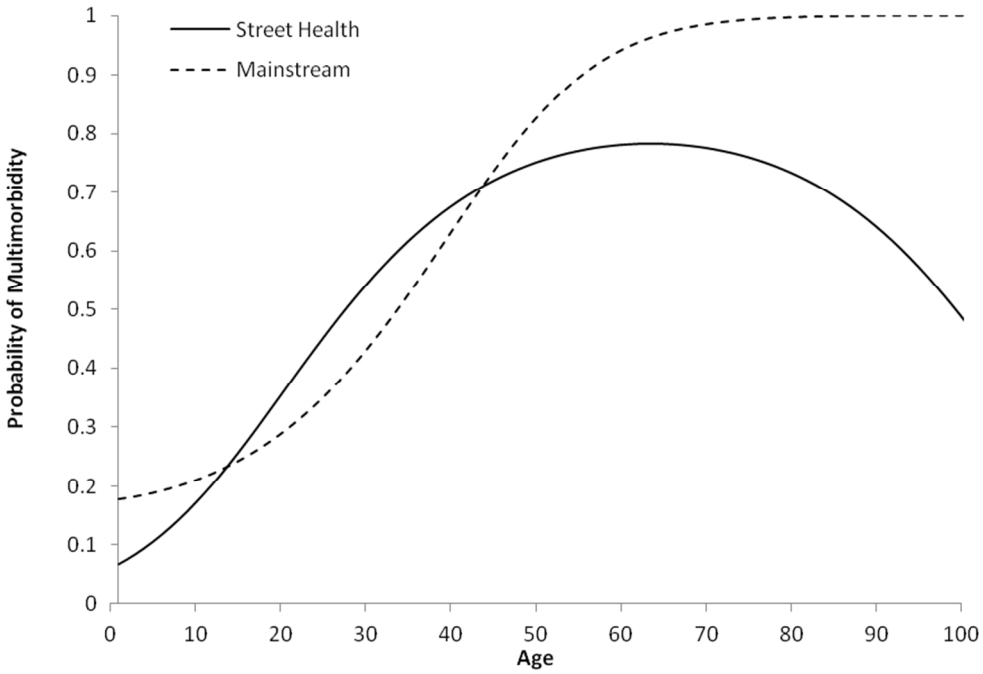

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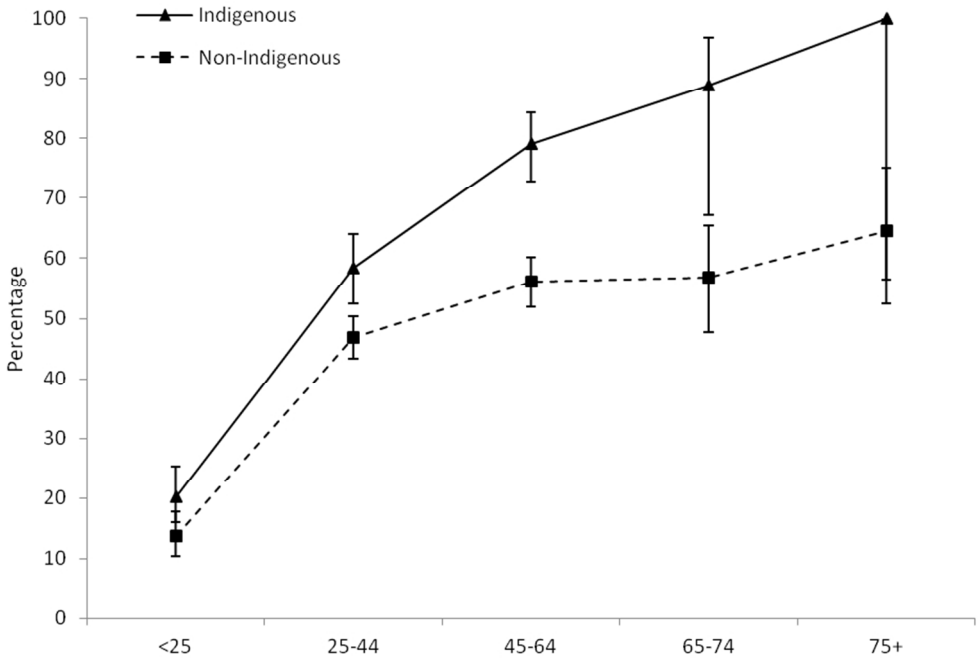

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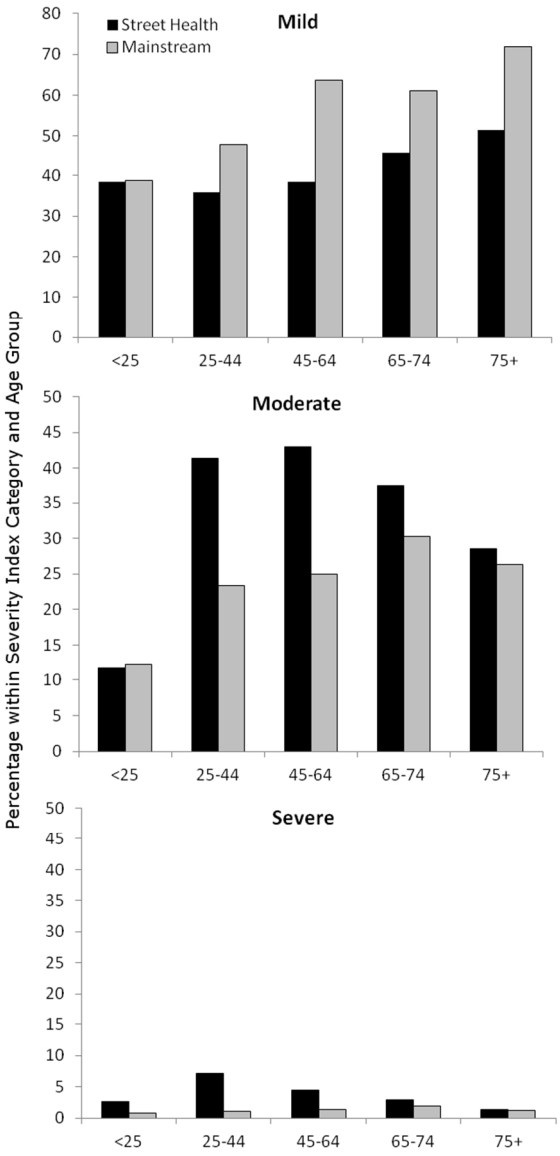

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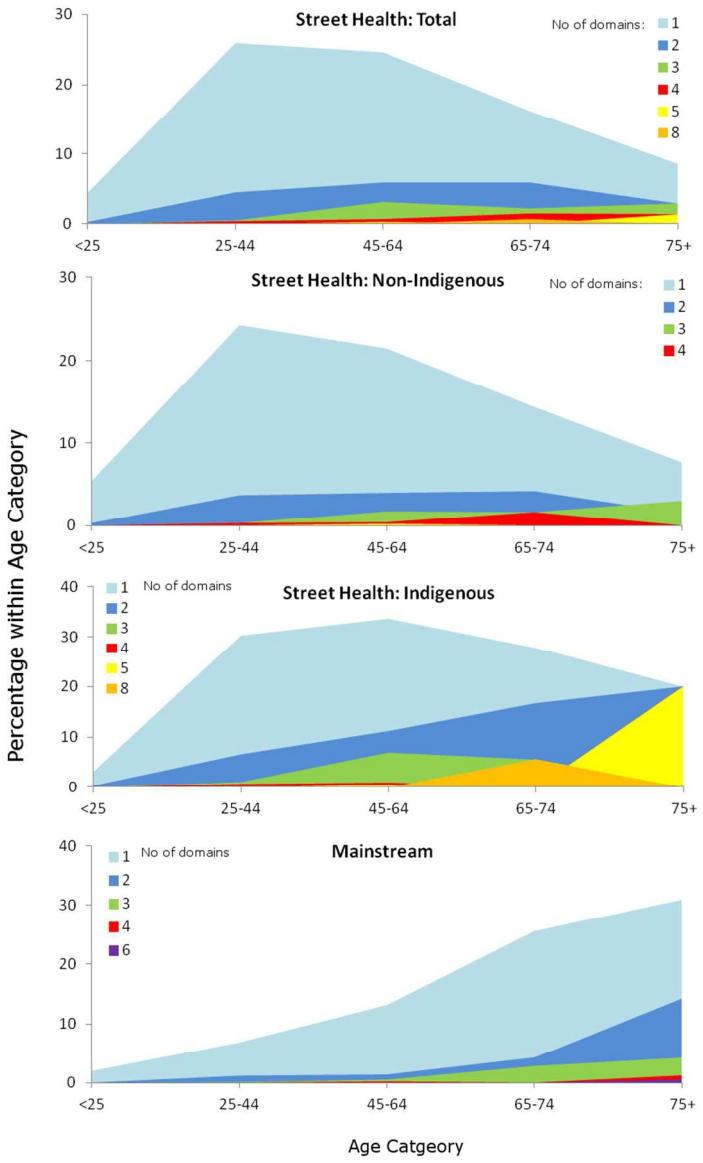

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No (Line No)
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Pg 1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Pg 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Pg 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Pg 5 (50-55)
Methods			
Study design	4	Present key elements of study design early in the paper	Pg 2 (9)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Pg 6 (7-15)
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Pg 6 (7-15)
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Pg 6 (18-48)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pg 7 (5-56) Pg 8 (3-8)
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	Pg 6 (7-15)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pg 6 (51-58) Pg 7 (3-59) Pg 8 (3-8)
		(*b*) Describe any methods used to examine subgroups and interactions	Pg 7 (41-56) Pg 8 (3-5)
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking	N/A

		account of sampling strategy	
		(*e*) Describe any sensitivity analyses	N/A
Results			**Page No (Line No)**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pg 9 (6-7)
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Pg 9 (7-54)
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Pg 10 (14) to Pg 15 (23)
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pgs 10-15
		(*b*) Report category boundaries when continuous variables were categorized	Pg 7 (11-27)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Pg 15 (15-54)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pg 16 (3-20)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pg 16 (24) to Pg 18 (8)
Generalisability	21	Discuss the generalisability (external validity) of the study results	Pg 18 (3) to Pg 19 (11)
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Pg 19 (16-27)

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.