Factors Associated with Intensive Care Unit (ICU) Admission Among Inpatients with and without Diabetes in South Western Sydney Public Hospitals Using the New South Wales Admission Patient Data Collection (2014 and 2017).

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Research Article

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Abstract

Background

South Western Sydney (SWS) is a hotspot for diabetes in Australia. We compared intensive care unit (ICU) admission risk between people with and without diabetes admitted to public hospitals in this metropolitan health district.

Methods

Retrospective study of all admissions to ICU in the New South Wales Admitted Patient Data Collection (APDC) over three years. Data on demographic and health insurance status, primary admission diagnosis, comorbidities including death in admission for public hospital inpatients aged ≥18 years residing in South Western Sydney were analysed. The ICU length of stay was the main outcome variable classified into short stay (≤48hrs) and long stay (>48 hrs) were analysed. Potential predictors were analysed for possible association with long ICU stay among people with and without diabetes admitted to the hospital.

Results

Of the 187660 inpatients from SWS in the three years, 3.5% spent at least one hour in ICU [5.0% with diabetes versus 3.3% without diabetes, $P<0.001$]. The median length of ICU stay was similar between people with and without diabetes [40hrs IQR 16-88 hrs versus 43hrs IQR 19-79hrs] as well as the prevalence of long ICU stay [44.9%, 95%CI 42.1, 47.7% versus 43.6%, 95%CI 42.2, 44.9%], respectively. A primary admission diagnosis of circulatory system disease was associated with long ICU stay in both groups, while male sex and a primary diagnosis of nervous system disease was associated with long ICU stay in the non-diabetes group only. Long ICU stay was associated with 1.6 times higher in-hospital mortality in people with diabetes.

Conclusions

ICU admission was more common in people with diabetes. One in every two admissions to ICU had a long stay, thereby increasing the resource utilization and was associated with higher in-hospital mortality. The predictors identified in the study can target this group to improve resource utilization and efficiency of ICU care. Additional population-based approaches to diabetes care are needed to reduce the risks of acute hospital admission.

Background

Diabetes is a major public health problem, with the worldwide prevalence of diabetes projected to double among adults from 463 million in 2019 to 592 million by 2035[1]. Diabetes contributes to 10% of total deaths in Australia[2], and the hospital admission rate for people with any diagnosis of diabetes has increased by 35% since 2000[3]. The rising trend in diabetes can be attributed to ageing, rapid urbanisation, and obesogenic environments[3].

Hospital inpatient care for people with diabetes makes up the largest medical expenditure in the US, accounting for 43% of the total medical costs in 2013 (US$409 billion) [4] . This is likely a combination of the increasing prevalence of diabetes, increasing hospital admission, long length of stay in people with diabetes. Admission to ICU could also significantly increase the medical cost, partly due to the high staffing ratios. It is often accepted that the length of stay in the ICU averages 24 hours [5] , and increasing ICU length of stay has been associated with higher 1-year mortality. [6] It is standard practice to have one nurse to one patient (1:1) for an ICU patient and one nurse to two (1:2) for high dependency patients. [7] In 2013/14 Critical Care Resources survey, a total annual operational cost for ICU care in Australia was estimated at $2119 million, which represents about 0.15% of gross domestic product (GDP) and 1.4% of total health care costs [8] . The cost of care for people with diabetes is projected to increase by 436% by 2033[9] and according to the Independent Hospital Pricing Authority estimates, the cost of ICU care in people with diabetes was about $210 per bed-hour or $5040 per ICU bed-day [10] . The increase in prevalence of diabetes coupled with the reported increase in diabetes related hospitalisations is likely to contribute to the increase in an already burdened health care system if proper measures to reduce admission and re-admission rates are not in place.

Residents of South Western Sydney (SWS) have poorer health outcomes and higher hospitalisation rates than the rest of the state[11]. The transition from the ICU has major implications for management of the hospitalized patients. The higher nurse to patient ratio in the ICU facilitates greater frequency of monitoring for example, the blood glucose measurement and the implementation of treatment protocols. This is in contrast to the lesser resources available on the wards for control of diabetes[12].

Limited data exist evaluating the influence of patient characteristics of people with and without diabetes, on ICU admissions during a hospital stay. Producing periodic prevalence estimates as well as identifying the predictors of ICU admission among inpatients with diabetes is needed to identify target groups for health promotion and diabetes management. This will also enable development of tools for scenario testing and effectiveness testing in future projections. In addition, ICU length of stay (LoS) has been suggested as a surrogate measure for assessing ICU resource utilization[13] as cost per day in ICU per patient is remarkably consistent across many diagnosis[14]. However, to date, there has been no Australian study of the effect of diabetes on ICU admissions. The paucity of such important data may lead to lack of uniform management policies across the country[15]. As part of a project to improve diabetes care in SWS local health district (LHD), this study was designed to investigate the factors associated with long ICU stay in admissions among people with and without diabetes over three–year period. The findings will lead to some practical suggestions for better utilization of the resources by targeting those at greater risk.

Methods

The New South Wales (NSW) APDC dataset[16] was used to identify people from SWS and compare demographic and admission related data for all inpatient admissions provided by state hospitals using International Classification of Diseases 10th revision, Australian Modification (ICD-10-AM). People were coded by their place of residence rather than admission hospital[16]. Since hospital admissions in Australia only occur in government hospitals, for this study, only public hospital APDC data of episodes of care was used, which has previously been validated in people with diabetes, and other populations[17-19]. When APDC data was used as a standard for validating self-reported diabetes status of people in the 45 and up study, the authors were able to identify 48.3% more people with diabetes whose status was not previously reported in their dataset.[20]

Study population

Data used in this study were for people resident in SWS who were admitted to a public hospital over 3 years (July 1, 2014 to June 30, 2017). All admissions to the ICU were included. Data were available for residents from 6 out of 7 local government areas (LGAs) in SWS where a total of 187,660 adults aged ≥18 years with and without diabetes were admitted to public hospitals. Data was analysed for people with and without diabetes and effect of year of admission (2014-15, 2015-16 and 2016-17) and residence (urban and peri-urban LGAs) based on the NSW Peri-urban Network of Council action plan[21], and ethnicity based on place of birth was assessed.

Ethics Approval

Approval for this study was obtained from the South Western Sydney Local Health District Human Ethics Research Committee as a quality improvement project (QA18/021) and study was conducted in accordance with the Declaration of Helsinki for human subject. **Informed consent was obtained from all participants at the time of admission, permission for use of de-identified data was obtained from the data custodian. All methods were performed in accordance with the relevant guidelines and regulations**

Statistical analysis

The outcome variable of this study was hour length of stay in ICU during admission, which was taken as binary: Short ICU stay defined as ICU stay of 1-48 hours and Long ICU stay as >48 hours during admission which was based from previous study[22]. Analyses were performed in STATA version 14.1 (Stata Corporation, College Station, TX, USA). Preliminary analyses involved frequency tabulations of all selected characteristics for people with and without diabetes who received intensive care during the study period. Prevalence estimates were examined against a set of all selected characteristics to assess the predictors of long ICU stay by diabetes status, including demographic, full hospital health insurance cover, primary admission diagnosis, and death. To plot long ICU stay by age in the category, we generated sampling weight to be '1' and used the Survey command in Stata to estimate prevalence and their corresponding 95% confidence intervals (CI). Simple and multiple logistic regression were used to identify

predictors of long ICU stay by diabetes status. In the unadjusted analyses, odds ratios (ORs) with 95%CI were calculated to assess the independent variable's unadjusted risk.

A staged modelling technique was adopted for the multiple logistic regression analysis in which level-factors were entered progressively into the model to assess their relationship with the study outcome[23]. In the first stage, demography factors were entered into the baseline multiple regression model to determine factors associated with the study outcome. Manual elimination process was used, and only variables associated with the outcome (P< 0.05) were retained as significant factors in the first model (model 1). In the second stage, financial factor was added to model 1, and those factors with P values <0.05 were retained in the second model (model 2) after the elimination process was carried out. In the third stage, primary admission diagnosis (ICD-10) factors were added to model 2. As before, those factors with P values <0.05 were retained in model three (model 3). Finally, the mode of separation from hospital (death) factor was added to model 3, and those factors with P values <0.05 were retained in the final model. The ORs and their 95%CIs derived from the adjusted logistic regression models were used to determine the predictors of long ICU stay in NSW.

Results

Profile of the study group

Of the 187660 residents of SWS who were admitted to the hospital during the study period, a total of 6557 people (3.5%) spent at least an hour in ICU admission. People with diabetes were more likely to be admitted to ICU (n=1216/24141, 5%) compared to those without diabetes (n=5341/163519, 3.3%; P<0.001). The median number of ICU hours spent by people with diabetes dropped from 46 (25th–75th percentile interquartile range IQR 19-96) hours to 43 (IQR 19-85, P<0.001) hours over the three years, but remained relatively stable in those without diabetes over three years. There was no significant difference between people with and without diabetes in terms of median length of ICU stay [40hrs IQR 16-88 hrs versus 43hrs IQR 19-79hrs].

Age distribution of ICU participants: Figure 1 shows the age specific prevalence long ICU stay for those with and without diabetes. Whereas older people with diabetes (aged 45years and over) spent more hours in ICU than those without diabetes, fewer hours in the ICU were recorded for the younger people with diabetes than their counterparts without diabetes.

Table 1 presents the characteristics of the participants admitted to ICU across SWS public hospitals between 2014 and 2017. Overall, more people with and without diabetes spent at least an hour in ICU in 2016-17 compared with 2014-15 and were mostly men aged 65 years and over.

Death in ICU: About 11.1% (n=135) of people with diabetes and 14.4% (n=769) of those without diabetes who received intensive care died during their hospital stay admission

Prevalence and unajusted analysis of associated factors of long ICU stay

Figure 2 shows the prevalence of long stay (> 48 hrs) in ICU among people with and without diabetes. Approximately 45% of the adults admitted to ICU had a long ICU stay, including 547 with diabetes and 2326 without diabetes.

Table 2 presents the prevalence and unadjusted analysis of factors associated with long ICU stay including the primary admission diagnosis over the study years. The proportion of people with diabetes who reported a long ICU stay was significantly reduced by 9% in 2016-17 compared with 2014-15. Simple logistic regression analysis revealed that age >44 years and having a circulatory system disease increases the odds for long ICU stay. Death during admission was also significantly associated with long ICU stay in people with diabetes (unadjusted odds ratio OR, 1.57, 95%CI: 1.09, 2.24), where more than half of them died during that admission.

In the non-diabetes group, men, and those aged 35 years and above, people whose primary diagnosis during admission was a circulatory system disease and those with any comorbidity during admission were more likely to report a long ICU stay. Also, people without diabetes admitted to the ICU for greater than 48hrs were more likely to die than survive during that admission (OR, 1.56, 95%CI: 1.34, 1.82).

Factors associated with long ICU stay among admitted people with and without diabetes.

Table 3 shows the adjusted odd ratios for the associations with long ICU stay in both groups. After adjusting for the potential confounders, people with diabetes admitted to the hospital in 2016-17 and those with a disease affecting the musculoskeletal system were less likely to have a long ICU stay than those admitted in 2014-2015 and did not have a disease affecting the musculoskeletal system. The presence of a circulatory system disease during admission increased the likelihood of long ICU stay by 1.4 folds.

After adjusting for all the potential confounders, men, people without diabetes who had a disease affecting the nervous and circulatory systems were more likely to have a long ICU stay, where as those without diabetes who were diagnosed with a musculoskeletal system disease on admission had a reduced odds for long ICU stay. The urban residency was associated with lower odds for long ICU stay compared with rural residency [aOR 0.83, 95%CI 0.74, 0.93], and in both diabetes and non-diabetes group, patients with a long ICU stay were more likely to die than survive during admission compared to those with shorter ICU stay.

Discussion

This study investigated the prevalence of long ICU stay using admission data for SWS residents over three years. The study found the following: 1) ICU admission for patients with diabetes is greater if they are admitted to hospital. 2), Patients admitted to ICU for >48 hours have poorer outcomes and increased risk of death. 3) Cardiovascular disease is a risk factor for long stay in ICU in patients with and without diabetes, and nervous system disease and female sex are risk factors for those without diabetes. While other investigators have reported findings similar to ours[13, 24], the present study provided a detailed

assessment of the factors associated with long ICU stay among admitted adults in an Australian setting using a nationally representative database. These findings suggest that more interventions in primary care or outpatient care, including introducing integrated care systems[25], may help improve diabetes care, avoid hospital admissions or shorten the patients' stay in ICU, as noted previously[26, 27].

The findings that long ICU stay was associated with increased risk of death in admission is contradictory to previous report of that the outcomes in people with long and short ICU stay in Saudi Arabia were similar[13]. Our findings must be interpreted in the proper context, keeping in mind that the definition of long ICU stay in the previous study was >14 days, involved only those in the medical/surgical ICU of a tertiary-care teaching hospital (not in primary care)[13]. In another study[22] where prolonged stay was defined as >48 hrs in ICU, the authors found that 19% of patients who underwent coronary bypass surgery had a prolonged ICU stay and this was a risk factor for death and readmission. Although some studies have also used a different definition for prolonged ICU stay (range from 3 to 14 days), they included only surgical patients[28, 29], people with diabetes complications[30] or those with intracerebral haemorrhage[25]. The study conclusions were limited to a very small number of patients (<5% of the original population), but all of the studies agree that prolonged ICU stay was associated with higher mortality rate (range from 15–33%). Nevertheless, half of the patients in the present study were in ICU for >48hrs and the present findings suggest that this high-risk group is worth investing to reduce the cost of care. This information is useful as decisions about continuing or withholding aggressive intensive care management based on long ICU stay may yield better outcomes. Emphasis should also improve ICU efficiency for those with and without diabetes without compromising the level of care.

The study identified certain factors associated with long ICU stay among admitted people in SWS, which can help plan strategies to improve resource utilization. The presence of a circulatory system disease in people with and without diabetes increased the likelihood of long ICU stay. In addition, having a circulatory or nervous disease was associated with higher likelihood of having a long stay in ICU in people without diabetes. Since patients with comorbidities stay longer and utilize more resources[13, 31], they constitute groups of patients worth investing in. It is also important that nurses recruited for ICU care have the proper background to care for patients with circulatory and nervous system diseases. It appears that patients admitted in the last year of this study (2016-2017) were less likely to stay longer than 48 hrs in ICU compared with those admitted in 2014-15 indicating some improvement in ICU care across SWS public hospitals.

The increased likelihood for ICU admission in people with diabetes compared with those without diabetes in Australia may reflect pre-existing comorbidity in people with diabetes. Among critically ill patients in India, 13.9% of the 1283 admissions in ICU over 4 years were established cases of diabetes, with 5.0% diagnosed as diabetes after admission. Past studies[17, 32] have also reported significant interaction between pre-existing hyperglycaemia and the association between acute glycaemia and mortality among people with diabetes in ICU[17]. In-hospital control of glucose in people with diabetes receiving ICU care is associated with a reduced length of hospital stay and lower mortality rate[32]. These findings suggest that

it is even more important to deal with diabetes management in primary care, help prevent hospital admission in the first place, and reduce the risk of ICU admissions and mortality.

The cost of hospital admission to patients may be a factor in the reduced risk of admissions in other countries, but in Australia, public hospitals do not charge for ICU care and hospital stay for Australian residents/citizens. Therefore, in this study, having private health insurance coverage does not appear to influence the length of stay in ICU and may not be a surrogate for socioeconomic status. In a study conducted in France among a low-income population with free access to health care, the researchers found higher hospitalisation and mortality rates for many diseases among people with access to free government health care than those without free access[33]. However, ICU care was not accessed.

ICUs admission is associated with greater utilization of hospital resources [13] and more in people with diabetes [34] with studies suggesting that this may be due the interaction between the longer LoS in hospital and the potential to receive emergency or intensive care during admission [34–36] . Lee et al [37] suggested that it cost the Australian government an average of A$5764 per admission to care for an individual with diabetes, and the cost increases by 1.3 times in people with diabetes who have both micro-and macrovascular complications. In this study, we found that people with diabetes needed more ICU care indicating the presence of complications. In a study using the Hospital Pricing Authority, researchers found that the Australian government spent about $210 per bed-hour or $5040 per bed-day for any individual who is admitted to ICU [8] . From this estimates to work out the cost per admitted patient in this study, we found that it cost about $5390 per year for those with diabetes and $5428 for those without diabetes in hospital across SWS with greater cost estimates when caring for those aged 45-54yrs. Although these are likely to be underestimated, because calculations were based on 2013 cost data, they did not consider the non-healthcare cost including costs of adverse events, glucose monitoring [37] and/or the impact of undiagnosed diabetes [34] both of which attract a higher cost; this group of patients with long-stay should be targeted for promotion of more optimal bed utilization by decreasing ICU length of stay. In the UK, the median cost per patient day in an ICU was estimated at US$1356 (range $1242–1745) [38] . A previous systematic review suggested that a regular source of primary care and a well-controlled HbA1c would reduce the likelihood of hospitalisation in people with diabetes [39] .

Strengths of this study include the provision of evidence of increased ICU care for general admissions of people with diabetes in Australia, and the large number of people included in the study as well as the use of place of residence rather than admitting hospital to define the population. The latter removes the bias associated with secondary/tertiary care centres, as well as including people admitted to hospitals outside the district. The main limitations of the study are due to the nature of the data being used (secondary data analysis). The dataset has the potential to be subject to coding errors at source, as with all administrative databases[40]. Although a previous study[41] found good agreement between self-reported diabetes and coded diabetes, a much higher inpatient prevalence of diabetes was found in an audit of inpatients in Melbourne.[42] Due to the higher length of stay for diabetes, the point prevalence will always be higher in hospital, but not as much when datasets like APDC look at all admissions. Data on the type

of diabetes was not extracted, country of birth was used as ethnicity and indigeneity are not routinely available. Additionally, de-identified data did not allow for the identification of multiple admissions, and data were not available for one of the seven LGAs in the district. Nobody mass index or glucose data was used in this study, and socioeconomic status data were also not available.

Conclusions

This study used data from NSW APDC to demonstrate that about one-half of the adult residents in SWS admitted to ICU in public hospitals over three years stayed in ICU for more than 48hours during same admission. Circulatory system disease was a risk factor for long ICU stay in both groups while nervous system disease and male gender were risk factors for long ICU stay among those without diabetes. Given the high economic and health burden of diabetes in the region, as evidenced by the high prevalence of long ICU stay, the greater likelihood of worse outcomes like death during long ICU stay, and the fact that people with diabetes were more likely to be admitted to ICU; there is a need for more integrated diabetes services, that cut across primary and secondary care. Some of the risk factors identified in this study are likely to reflect the high local diabetes prevalence associated with lower socioeconomic groups and ethnic minority populations. New strategies that target the groups at the highest risk identified here should be considered. Such an approach could bridge the gap between Australian State and Federally funded services to reduce ICU admissions and improve outcomes in people with diabetes.

Abbreviations

SWS: South Western Sydney

NSW: New South Wales

SWSLHD: South Western Sydney Local Health District

LGA: Local Government Area

ABS: Australian Bureau of Statistics

NSW APDC: New South Wales Admitted Patient Data Collection

ICU: Intensive Care Unit

HbA1c: Glycated haemoglobin A1c

CVD: Cardiovascular disease

LoS: Length of stay

OR: Odds ratio

aOR: Adjusted odds ratio

ICD-10: International classification of diseases, tenth version

CI: Confidence interval

Declarations

Ethics approval and consent to participate

Approval for this study was obtained from the South Western Sydney Local Health District Human Ethics Research Committee as a quality improvement project (QA18/021) and study was conducted in accordance with the Declaration of Helsinki for human subject. **Informed consent was obtained from all participants at the time of admission.**

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study are included in this published article. Data is also **publicly available on request from the Centre for Health Record Linkage, which is managed by the NSW Ministry of Health. Available at:** https://www.cherel.org.au/data-dictionaries#section1

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

ULO and MP conceptualized the study, ULO and KA designed and interpreted the data regarding the ICU rates and factors associated with long stay. KA performed the statistical analysis while ULO, MX, DS and MP were major contributors to interpreting the data. ULO and MX drafted the manuscript while all authors contributed to reviewing the manuscript. DS supervised the study. All authors read and approved the final manuscript.

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Figures

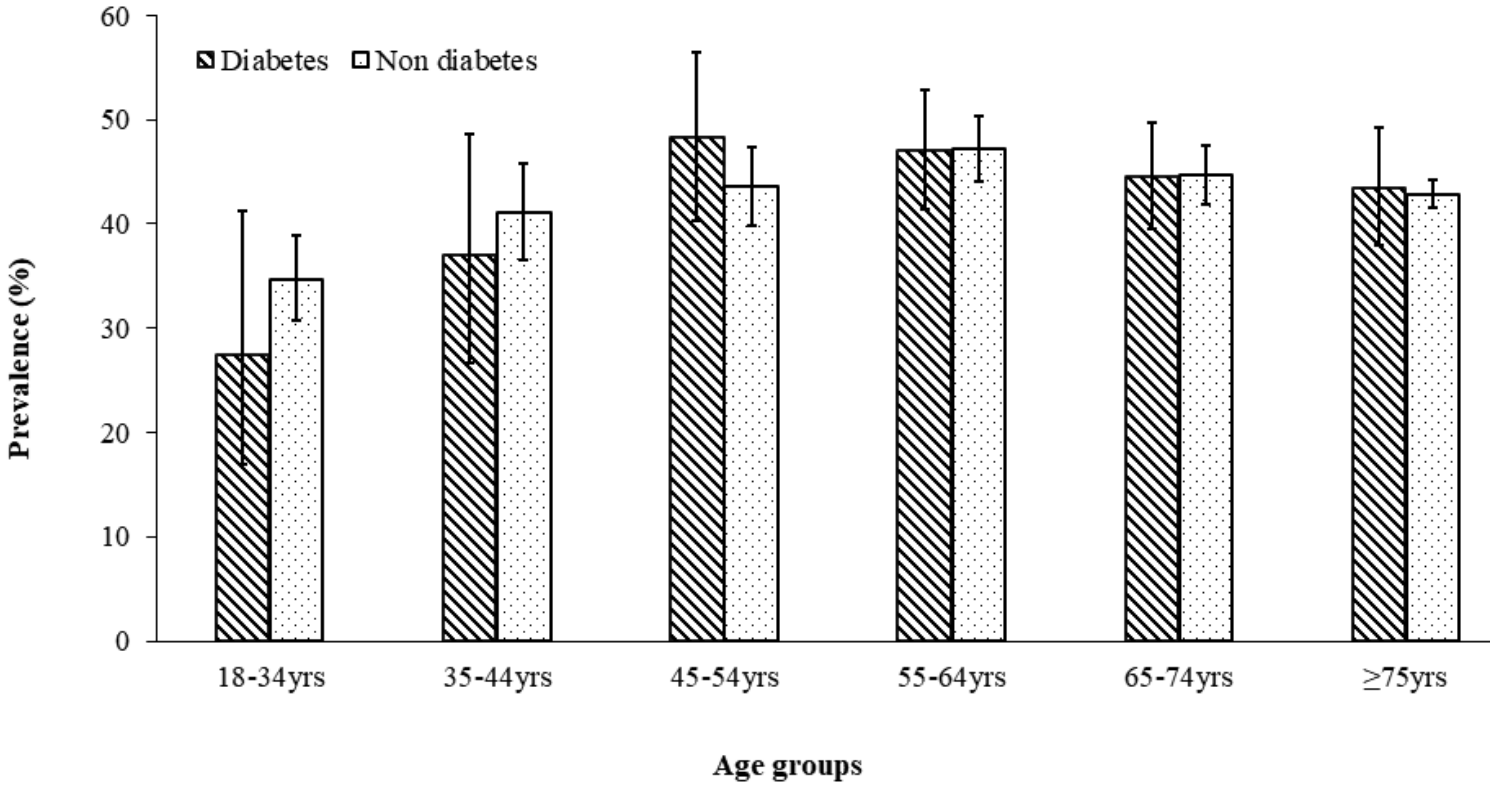

Figure 1

Age specific prevalence of long intensive care unit (ICU) stay. Error bars are 95% confidence intervals

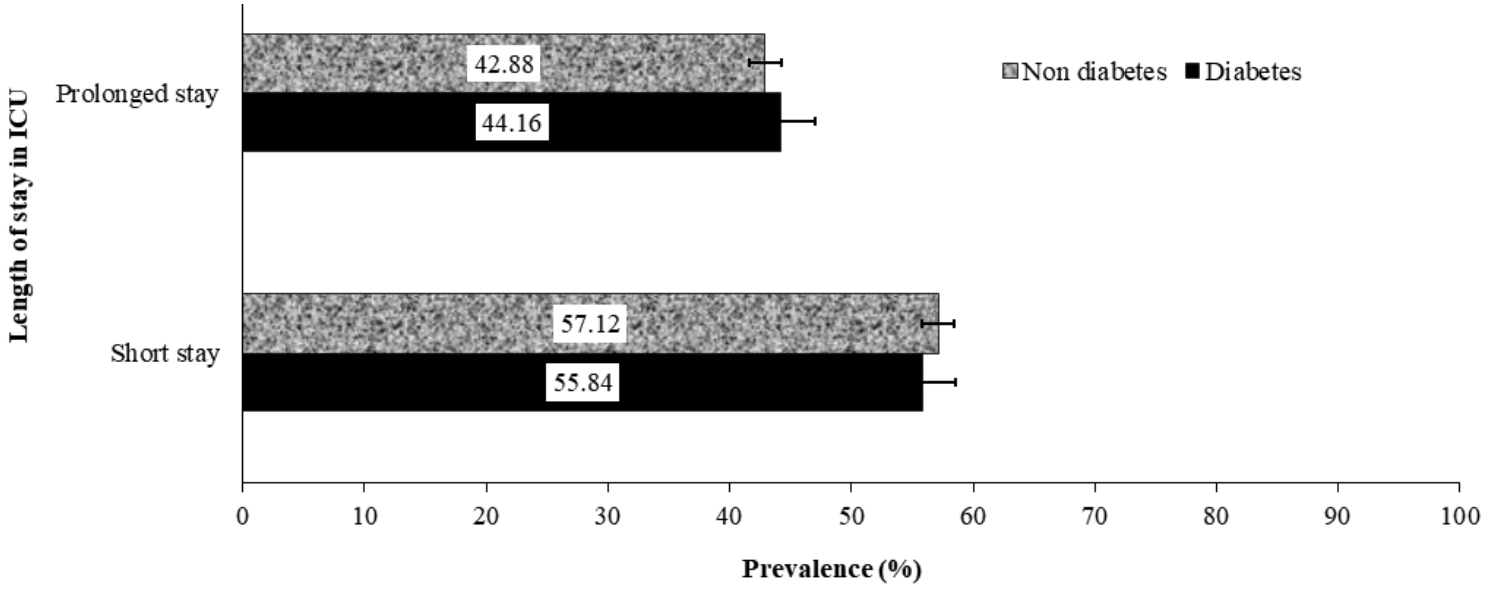

Figure 2

Prevalence of long and short Intensive care unit (ICU) stay. Error bars are 95% confidence intervals