Diabetic ketoacidosis admissions at Middlemore Hospital: observational study of cause and patient demographics

Jessica Heejong Lee, Brandon Jon Orr-Walker

Diabetic ketoacidosis (DKA) is a serious complication of diabetes. While mortality has improved in recent years to less than 1% in most developed countries, it is associated with high healthcare utilisation and costs. There have been studies showing certain demographic characteristics to be associated with higher risk of developing DKA, including lower socioeconomic status and younger age. The data on association between ethnicity and DKA risk have been somewhat variable with some US studies showing an association and others showing no association. Given the regional variations in ethnic distribution and differing degrees of income disparity, there is likely to be significant geographical difference concerning ethnicity as a risk factor.

In traditional literature, there was emphasis on infection or other illnesses as the precipitant of DKA, but more recent studies have shown non-adherence as the major cause. An observational study in inner-city US where there is a greater proportion of patients of lower socioeconomic status and ethnic minority, found that 68% of DKA were due to insulin discontinuation. A local study from Auckland City Hospital using data from 1988 to 1996 showed that 61% of DKA admissions were due to insulin omission, and a Middlemore Hospital study from 1999–2000 showed 45% of DKAs were attributable to non-adherence.

Given this context, it was of interest to determine how the current situation at

---

**ABSTRACT**

**AIM:** To analyse data on diabetic ketoacidosis (DKA) admissions to better understand characteristics of those presenting with DKA and identify high-risk groups.

**METHOD:** Study population consisted of people with type 1 diabetes discharged from Middlemore Hospital between 01 July 2015 and 30 June 2016 with the diagnosis of DKA. Basic demographic data and socioeconomic status as defined by 2013 New Zealand deprivation index quintiles were obtained, in addition to the cause of DKA.

**RESULTS:** There were 69 DKA admissions from 57 people; 35% were Pasifika and 23% Māori. Fifty-six percent were from quintile 5, the quintile with the lowest socioeconomic status. The most common cause of DKA was non-adherence to insulin (59%), followed by infection (16%) and new diagnosis of type 1 diabetes (14%). There was greater proportion of Pasifika and Māori population in those with non-adherence as the cause.

**CONCLUSION:** Non-adherence is a major cause of DKA admissions at Middlemore Hospital. When compared to the regional census data, there is over-representation of Pasifika and Māori population and those of lower socioeconomic status in those admitted with DKA. Similar pattern was seen in those with non-adherence as the cause of DKA and those with recurrent DKAs.
Middlemore Hospital aligns with findings from these previous reports, and to see whether particular high-risk groups could be identified. This is a retrospective observational study looking at the cause of DKA and patient characteristics including basic demographic data and presence of previous DKA admissions, in order to gain a better understanding of DKA admissions at Middlemore Hospital. Also, upon obtaining the above data, additional analyses were undertaken for comparisons between groups by cause of DKA and presence of previous DKA admissions.

**Aim**

To analyse retrospective data on DKA admissions including the cause of admission and baseline characteristics of patients in order to better understand characteristics of those presenting with DKA, and to identify high-risk groups.

**Method**

Prior to starting data collection, Middlemore Hospital Research Department was consulted regarding ethics approval, and in accordance with Health and Disability Ethics Committees (HDEC) guideline algorithm, this study was deemed to be a low-risk observational study.

Study population consisted of all people who were discharged from Middlemore Hospital adult services (age ≥15) in the one-year period between 1 July 2015 and 30 June 2016 with the diagnosis of DKA. DKA was defined as presence of hyperglycaemia (>13.9mmol/L), and acidosis with pH <7.3 and HCO₃<18mmol/L with evidence of ketoacidosis, as per American Diabetes Association (ADA) criteria. Patients with type 2 diabetes were excluded from the analysis.

A list of people with discharge ICD codes relating to diabetes with any form of ketoacidosis (E1011, E1012, E1111, E1112, E1211, E1212, E1311, E1312, E1411, E1412) was obtained, together with basic demographic data including age, gender, ethnicity (self-identified) and socioeconomic status from hospital patient records. Socioeconomic status was defined by quintiles based on the 2013 New Zealand Deprivation index, which was the most current version at the time of data collection. The New Zealand Deprivation index quintiles apply to areas of residence as opposed to individuals, and are derived from New Zealand census data including internet access, income, employment, education, home ownership, living space, access to transport and being a single-parent family. Quintile 5 is the most deprived area and quintile 1 is the least deprived.

The electronic discharge summaries and laboratory results from the admissions with the relevant ICD codes were reviewed, and those fulfilling the ADA diagnostic criteria for DKA were identified. Of these patients, only those admissions relating to type 1 diabetes were identified and used for analysis. Diagnosis of type 1 diabetes was established by reviewing the documented diagnosis in diabetes clinic notes and discharge summaries. Cause of DKA was determined by review of discharge summaries relating to the admission; non-adherence was deemed to be the cause when stated as such, and/or if there was mention of insulin omission leading up to the DKA admission.

**Study population and statistical analysis**

Of the 164 admissions that were identified using the ICD codes, 76 admission episodes fulfilled the ADA diagnostic criteria for DKA. Of the 76 DKA admissions, 69 admissions occurred in those with type 1 diabetes. These 69 admissions were from 57 individuals with type 1 diabetes, there being more than one admission in some people during the captured period.

For analysis of factors relating to the DKA episode such as the cause of DKA, all of the 69 DKA admission episodes were used for analysis. For factors relating to the individual such as age, gender, ethnicity and socioeconomic status, the data was based on the 57 people from which the 69 DKA episodes came, with only the data from the most recent admission from each person being used for analysis. When comparisons were made based on cause of DKA and between those with single versus recurrent DKA admissions, we used data from 47 patients with established type 1 diabetes, using the most recent admission from each, given the comparison relates to characteristics of the individual, in order to avoid repeated measures from one person.
Use of p-values for statistical significance was decided against, in favour of descriptive statistics only, due to potential for misinterpretation given small size, unbalanced groups and confounding variables which could not be accounted for within the scope of this study.

### Results

**Patient characteristics**

Of the 57 individuals with type 1 diabetes admitted with DKA, 27 (47%) were male, showing roughly equal gender distribution. Almost half (49%) were below the age of 30, with 19% being below the age of 20. With regards to ethnicity, 35% (n=20) identified as Pasifika and 23% (n=13) Māori.

Middlemore Hospital is the only tertiary hospital for the region under Counties Manukau District Health Board (CMDHB). When compared to CMDHB census data, there seemed to be an over-representation of Pasifika and Māori as they make up only 21% and 16% of CMDHB population as a whole, respectively (Table 1). While there is no registry of people with type 1 diabetes in CMDHB, given type 1 diabetes is not known to be more prevalent in Pasifika or Māori population, there is likely an over-representation of these ethnicities in DKA admissions.

Similarly, there was a predominance of people of lower socioeconomic status, with 56% (n=30) of patients being from quintile 5; as with ethnicity, in the context of CMDHB population data as a whole, there is an over-representation of lower socioeconomic groups as 2013 CMDHB census data showed that 36% of CMDHB population are quintile 5 (Figure 1).

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Middlemore DKA patients (%)</th>
<th>2013 CMDHB Census Data (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>European/Other</td>
<td>37%</td>
<td>40%</td>
</tr>
<tr>
<td>Asian</td>
<td>5%</td>
<td>23%</td>
</tr>
<tr>
<td>Pasifika</td>
<td>35%</td>
<td>21%</td>
</tr>
<tr>
<td>Māori</td>
<td>23%</td>
<td>16%</td>
</tr>
</tbody>
</table>

| Figure 1: Socioeconomic status of DKA patients as per NZDep 2013 quintiles. |
DKA episode characteristics

The cause of DKA was non-adherence to insulin in the majority of people (59%, n=41); this was followed by infection (16%, n=11) and new diagnosis of type 1 with DKA as first presentation (14%, n=10). In three patients (4%) the cause was not found or documented, and in two people (3%), there were issues with administration of insulin due to insulin pen malfunction and incorrect administration by staff in the care facility. There was one individual who had major depression and stopped all medications. Of those with infection as the cause, 54% were due to respiratory infection and 36% were attributed to gastroenteritis; however, there may have been an overestimation of gastroenteritis with vomiting from DKA itself being attributed to gastroenteritis.

With regards to treatment setting, 54 (78%) of admissions were treated on the ward, eight (12%) in intensive care unit (ICU), six (9%) in high dependency unit (HDU). One case of DKA was treated and discharged from the emergency department.

DKA in people with established type 1

People with established type 1 diabetes were looked at separately, by excluding those with DKA as first presentation of type 1 diabetes. This group consisted of 59 DKA admissions from 47 people.

a. Non-adherence versus other cause of DKA

In those with established type 1 diabetes, 69% (n=32) of DKA admissions were due to non-adherence.

In those with non-adherence as the cause of DKA, 22% (7/32) were on mixed insulin as opposed to basal bolus regimen. In those with other cause of DKA, only 7% (1/15) were on mixed insulin. This likely reflects the fact that people who are known to have significant problems with adherence are often changed to mixed insulin in an attempt to improve adherence, but could also be taken in reverse to suggest that despite being on mixed insulin they are still non-adherent.

With regards to socioeconomic status, 63% of patients with non-adherence as the cause were quintile 5, compared to 47% in those with other cause. Overall lower socioeconomic status predominated in both groups but this was more pronounced in those with non-adherence as the cause of DKA.

The difference in ethnicity between the two groups was more noticeable. In the non-adherence group, 44% (n=14) were Pasifika, followed by Māori (31%, n=10), European (22%, n=7) and one patient who was Indian (3%). In the group with other cause of DKA, 53% (n=8) were European, followed by Pasifika (27%, n=4) and Māori (20%, n=3). Average HbA1c was higher (110mmol/mol (12.2%) vs 99mmol/mol (11.2%)) in those with non-adherence as cause.

b. Recurrent admissions versus single admission with DKA in five years

For people with established type 1 diabetes, the number of previous admissions with DKA in the five-year period preceding the index case was noted. For individuals with multiple admissions during the study period, the most recent admission was used as the index case to avoid repeated measures from one individual. Fifty-one percent (24/47) had no previous DKA admissions in the five years preceding their index case, and the remaining 49% (23/47) had varying numbers of previous admissions ranging from one to 23. Comparison was made between those with recurrent admissions versus those with no preceding DKA admissions.

In those with recurrent admissions, Pasifika made up 48% (n=11), followed by European (26%, n=6), Māori (22%, n=5) and Indian (4%, n=1). In those with no preceding DKA admissions, European ethnicity consisted of 38% (n=9), followed by Māori (33%, n=8) and Pasifika (29%, n=7) (Figure 2).

While those in quintile 5 were most prevalent in both groups, this was more pronounced in those with recurrent DKA admissions, with 70% being from quintile 5, compared to 46% in those with no preceding admissions. Gender distribution was similar between the two groups. In those with recurrent admissions, average age was slightly higher (29 vs 26.5 years), average HbA1c was higher (112mmol/mol (12.4%) vs 99mmol/mol (11.2%)) and more had non-adherence as the cause of DKA (74% vs 63%).
Discussion

On review of overall DKA admissions, it is likely that there is an over-representation of Pasifika and Māori population and those of lower socioeconomic status (quintile 5), when compared to the CMDHB census demographic data.\(^9\) However, it should be noted that in the absence of a registry of all people with type 1 diabetes at CMDHB, it is difficult to say with certainty whether predominance of certain characteristics in those admitted with DKA represents increased risk of DKA admission in those with said characteristics, or whether it reflects predominance of these characteristics in people with type 1 diabetes in general. That being said, type 1 diabetes is not known to be more prevalent in Pasifika or Māori populations; a study from Christchurch suggested the contrary, showing it to be more prevalent in those of European ethnicity, with estimated prevalence per 100,000 of 274 for Europeans, 81 for Māori and 77 for Pasifika.\(^1\) Therefore, it is much more likely that Pasifika and Māori patients are in fact over-represented in DKA admissions.

The most common cause of admission was non-adherence to insulin, which was the cause in 59% of all people with type 1 diabetes, and in 69% of people with established type 1 diabetes. This is comparable to the Auckland City Hospital study from 1988–1996, which showed that 61% had DKA due to insulin omission,\(^8\) but greater than the previous Middlemore Hospital study in 1999–2000 showing that 45% of DKA admissions were attributable to non-adherence.\(^9\)

This study was designed as an observational study and was not intended for formal comparisons between any groups. Sample size is small and as the scope of this study was mostly limited to patient demographics, data on other possible confounding variables to allow for multivariate analysis such as duration of diabetes, age at diabetes diagnosis, BMI and severity of diabetes related complications were not available, and hence p-values were not used to avoid misinterpretation. In addition, with regards to identification of DKA admissions, the reliability of ICD coding is to be questioned. While all those identified using ICD codes were appropriately filtered to only those fulling ADA criteria for DKA, there is a possibility that some cases of DKA were missed due to incorrect coding in case of inaccurate or incomplete documentation of discharge diagnoses in discharge summaries. For future studies, using laboratory data such as levels of beta hydroxybutyrate and pH on admission to identify more cases should be a consideration, although there may be practical difficulties and is likely to result in a large number of cases not meeting criteria.

\(^{11}\)
Nevertheless, there were some noticeable patterns in between the groups compared. The group with DKA due to non-adherence had higher proportions of Pasifika and those of lower socioeconomic status (quintile 5), in addition to higher average HbA1c. Fifty-one percent of people with established type 1 diabetes had previous DKA admissions in the preceding five years, and these people also had higher proportions of Pasifika and quintile 5 patients, in addition to having higher average HbA1c.

Overall, Pasifika and quintile 5 seem to be over-represented in overall DKA admissions, in having non-adherence as the cause for DKA, as well as in having had recurrent DKA admissions. Lower socioeconomic status has been found to be associated with increased DKA risk in previous studies including the US study based on Type 1 Diabetes Exchange Clinic Registry; of interest, this study showed higher frequency of DKA in non-Hispanic black and Hispanic participants, but ethnicity was no longer found to be significant once adjusted for socioeconomic status in multivariate model.4 To confirm suspicion of over-representation of Māori and Pacific Island ethnicity on DKA risk and non-adherence, future studies with bigger population size and multivariate analysis are needed; it should be acknowledged, however, that factors such as ethnicity and socioeconomic status often have a complex and often inseparable relationship with multiple historical and cultural elements underlying.

Further studies are also needed to better delineate the contributing factors for such over-representation Māori and Pasifika. Inadequate access to healthcare due to financial and transport barriers has been identified as the cause of non-adherence to insulin in DKA patients in the past.12 Future studies should obtain more information on level of education, factors affecting access to healthcare including transport, financial barriers, language barriers, ownership of a phone or other modes of communication, and presence of a fixed abode. Medical co-morbidities especially psychiatric, including substance or alcohol abuse which have previously been associated with increased risk of DKA also need to be explored in more detail.13,14 To better determine factors affecting adherence to insulin, a survey of reason for insulin omission when patients are admitted with DKA could potentially provide useful information. Especially in a multi-ethnic country such as New Zealand, it is of importance to consider the cultural aspects which may be compromising diabetes management, including individual and institutional racism, differences in communication styles, health and dietary beliefs, and adequacy of current policies in addressing ethnic inequity.15 Identifying these specifics may help in better determining the areas of intervention and the target population. Lastly, establishing a registry of all individuals with type 1 diabetes at CMDHB would be useful in the long-term in better identifying those at higher risk of DKA; such a registry would also allow comparison of people with history of previous DKA with those without, which would be a useful clinical comparison.

**Conclusion**

Non-adherence is a major cause of DKA admissions at Middlemore Hospital. In addition, there is suggestion of over-representation of Pasifika and Māori ethnicity, and those of lower socioeconomic status in those admitted with DKA. A similar trend was seen in those with non-adherence as the cause of DKA and those with recurrent DKAs. Further studies are needed to better delineate the underlying factors for this observation, including medical co-morbidities and factors affecting access to healthcare.
Competing interests:
Nil.

Author information:
Jessica Heejong Lee, Registrar, Department of Medicine, North Shore Hospital; Brandon Jon Orr-Walker, Endocrinologist, Department of Endocrinology, Middlemore Hospital.

Corresponding author:
Jessica Lee, Department of Medicine, North Shore Hospital, Shakespeare Road, Takapuna, Auckland 0622.
drjessica.lee2@gmail.com

URL:

REFERENCES: