Digit preference bias in the recording of emergency department times

Thomas E. Locker and Suzanne M. Mason

Objective Digit preference bias has previously been described in a number of different clinical settings. The paper aimed to assess whether digit preference bias affects the recording of the time patients arrive and leave emergency departments.

Method An observational study of 137 emergency departments in England and Wales was conducted. Each department was asked to submit details of the time of arrival and time of departure from the emergency department for each patient attending during April 2004. In addition, interviews with the lead clinician were undertaken to determine the method used to record the time of departure. The degree of digit preference bias was assessed using a modification of Whipple's index.

Results One hundred and twenty-three (86.9%) departments submitted data detailing 648 203 emergency department episodes. 114875 (18.0%) episodes had a recorded minute of departure of '0' or '30', with a further 2 81 890 (44.1%) having other values with a terminal digit of '0' or '5'. The mean modified Whipple's index for time of departure was 316.9 (range 70.9–484.4). Linear regression demonstrates a small but significant inverse relationship between the modified Whipple's index and the mean total time in department ($b = -0.05$, 95% CIs -0.09 to -0.0004, $P = 0.048$).

Conclusion Some departments show considerable digit preference bias in the recording of time of departure from the emergency department. Such bias may cause difficulty in assessing changes in the performance of departments.*European Journal of Emergency Medicine* 13:99–101 © 2006 Lippincott Williams & Wilkins.

Correspondence and requests for reprints to Thomas E. Locker, School of Health and Related Research, University of Sheffield, Regent Court, 30 Regent Street, Sheffield S1 4DA, UK
Tel: + 44 114 222 0868; fax: + 44 114 222 0749;
e-mail: t.locker@sheffield.ac.uk

Introduction
The total length of time patients spend in the emergency department (ED) is a frequently used measure of performance. Meaningful determination of this time is dependent upon the accurate recording of both the time the patients arrive in the ED and the time they leave. Although it is commonplace for the patients' time of arrival in the ED to be recorded automatically by computer as part of the registration process in the ED, some EDs record the time patients leave the department manually, this being transcribed from the ED records to a database at a later stage. Manual systems of recording ED times leave scope for digit preference bias to arise. Digit preference bias describes the tendency for individuals to record numbers that end with a particular digit such as zero or five. Digit preference bias has been previously described in situations when patients are asked to report data such as age, year of menopause and smoking rate, and in situations when clinicians are responsible for recording measurements such as blood pressure and birthweight [1–5]. The presence of digit preference bias has also been used to detect fraud in clinical trial data [6].

The aim of this paper was therefore to determine whether digit preference bias occurs in the recording of times within EDs and whether this is influenced by the use of manual vs. computerized systems to record this information. A further aim was to explore whether there was any association between the degree of digit preference bias exhibited and the performance of the EDs studied.

Methods
The 'United Kingdom Waiting times in Accident and Emergency Departments–Influence of Organizational Factors Study' (UWAIT) is a study of factors that influence waiting time in EDs. All major EDs (type 1) in England and Wales were invited to participate in the UWAIT study. Major EDs are those that provide a consultant-led 24 h service with full resuscitation facilities and designated accommodation for the reception of accident and emergency patients [7]. Each participating department was asked to submit data for each new patient attending their department during April 2004. For each patient, the date and time of arrival and of leaving

the ED were collected. In addition, interviews were conducted with the lead clinician in each department to determine the methods used to record a patent's time of departure. The methods used to record the time of departure were classified as 'computerized' if this was undertaken using a computerized system at the time the patient left the ED and 'manual' when the time was recorded by hand in the patient's ED notes and transcribed to a computerized system at a later stage.

From these data, the minute of a patients' time of arrival and time of departure from the ED was determined for each patient episode. The frequency of each value was determined for each department. The degree of digit preference bias for values ending in '0' or '5' was determined using a modification of Whipple's index. The degree of bias was calculated according to the following formula:

$$\text{Modified Whipples index (MWI)} = \frac{\sum(n_0 + n_5 + n_{10} \ldots n_{55})}{1/5 \times \sum(n_1 + n_2 + n_3 \ldots n_{59})} \times 100.$$

This method assumes an even distribution of values from '0' to '59'. The MWI may range from zero, when no values end in '0' or '5', to 500 indicating that all recorded times end in these values. A value of 100 indicates there is no digit preference bias. The MWI was calculated for each department.

The total time patients spent in the ED was defined as the difference between the time of arrival and time of departure, the mean of these times being determined for each department. Linear regression was used to examine the relationship between the mean total time in department and the degree of digit preference bias, assessed by the MWI.

Results

One hundred and thirty-seven departments consented to take part in the UWAIT study. Of these, five (3.7%) were unable to abstract the data from their information technology systems and nine (6.6%) did not provide data. One hundred and twenty-three (86.9%) departments submitted the required data detailing 648 203 ED episodes. Of these, 9018 (1.4%) episodes had incomplete data for either the time of arrival or time of departure and were therefore excluded from further analysis.

Graph 1 shows the distribution of recorded minute of arrival and departure. It can be seen that there is little digit preference bias in the recording of time of arrival with a mean MWI of 108.6 (range 66.1–279.4). The recorded minute of departure shows considerable clustering around values with a terminal digit of '0' or '5'. 114875 (18.0%) episodes had a recorded minute of departure of '0' or '30', with a further 281 890 (44.1%) having other values with a terminal digit of '0' or '5'. The mean MWI for time of departure was 316.9 (range 70.9–484.4).

The method of recording time of departure was known in 105 (85.4%) departments, of which 42 (40%) recorded the time of departure using computerized systems and 63 (60%) recorded the time manually. Departments in the latter group had a significantly higher mean MWI (375.7 vs. 213.7, $t(103) = 6.312$, $P < 0.001$).
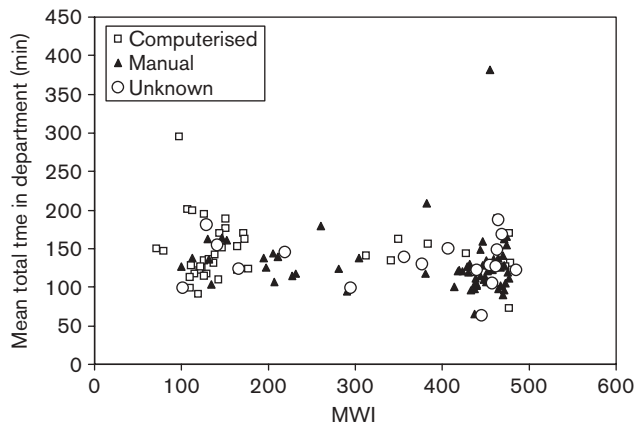
Graph 2 shows the relationship between each department's MWI and the mean total time patients spent in

Graph 1
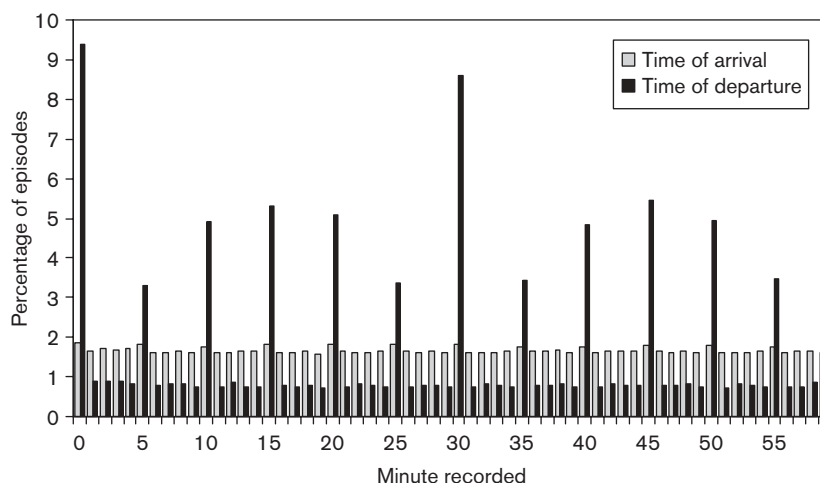
Distribution of the recorded minute of arrival and departure.

Graph 2

Modified Whipple's index vs. mean total time in the department by method of recording time of departure.

that ED. Linear regression demonstrates a small but significant inverse relationship between MWI and the mean total time in department ($b = -0.05$, 95% CIs -0.09 to -0.0004, $P = 0.048$).

Discussion

This study shows that some EDs show marked digit preference bias in the recording of the time that patients leave the ED. This effect is more prominent in those departments in which manual systems of recording time are used. Does this matter? Limited evidence from this study reveals that increasing degrees of digit preference bias are associated with lower mean total times in the department, although this effect is small. Why this effect should occur is difficult to assess from the data collected. It is possible that manual systems of recording the time leaving the ED, although associated with increased digit preference bias, might be quicker than recording the times directly onto an information technology system. Equally, it is possible that there is a tendency to underestimate the time the patient leaves the ED when this is recorded manually and hence those departments in which such systems of recording are used exhibit greater digit preference bias but show better performance.

Perhaps of greatest importance is the difficulty of assessing changes in performance in departments that exhibit large degrees of digit preference bias. In this study, 18.0% of episodes had a recorded time of departure ending in '0' or '30'. If one assumes the distribution of the minute of departure to be uniform from '0' to '59' minutes, then the expected proportion of times ending in '0' or '30' would be 3.3%. Thus, the data collected suggest that 14.7% of episodes are having their time of departure rounded up or down to the nearest 30 min. This may cause difficulties when departments are attempting to detect changes in their performance in response to alterations in service provision. Performance targets for EDs in England specify that 98% of patients should spend no longer than 4 h in the ED. The data presented in this paper cast doubt upon the ability of current systems to accurately monitor the length of time patients spend in the ED. This, in combination with the distribution of total time patients spend in the ED that we have previously reported, casts significant doubt upon the reported performance of EDs in England [8].

Evidence shows that a change from manual to automated systems of recording blood pressure results in lower degrees of digit preference bias [4]. The finding that in this study departments with computerized systems of recording show less digit preference bias than those with manual systems would suggest that a reduction in this effect might be achieved with a move to computerized systems of recording.

We would suggest that in future, part of the performance monitoring of EDs should include an assessment of the quality of data used to determine their performance.

Acknowledgement

References

1 Denic S, Khatib F, Saadi H. Quality of age data in patients from developing countries. *J Public Health (Oxford)* 2004; **26**:168–171.

2 Crawford SL, Johannes CB, Stellato RK. Assessment of digit preference in self-reported year at menopause: choice of an appropriate reference distribution. *Am J Epidemiol* 2002; **156**:676–683.

3 Klesges RC, Debon M, Ray JW. Are self-reports of smoking rate biased? Evidence from the Second National Health and Nutrition Examination Survey. *J Clin Epidemiol* 1995; **48**:1225–1133.

4 McManus RJ, Mant J, Hull MR, Hobbs FD. Does changing from mercury to electronic blood pressure measurement influence recorded blood pressure? An observational study. *Br J Gen Pract* 2003; **53**:953–956.

5 Edouard L, Senthilselvan A. Observer error and birthweight: digit preference in recording. *Public Health* 1997; **111**:77–79.

6 Al-Marzouki S, Evans S, Marshall T, Roberts I. Are these data real? Statistical methods for the detection of data fabrication in clinical trials. *BMJ* 2005; **331**:267–270.

7 Report by the Comptroller and Auditor General. Improving emergency care in England. London: National Audit Office; 2004. Report by the Comptroller and Auditor General.

8 Locker TE, Mason SM. Analysis of the distribution of time that patients spend in emergency departments. *BMJ* 2005; **330**:1188–1189.