Determinants of patient-reported medication errors: a comparison among seven countries

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SUMMARY

Objective: Medication errors are a frequent cause of adverse drug events and a major concern for patient safety. This study compared the predictors of error among seven countries (Australia, Canada, New Zealand, the United Kingdom, the United States, Germany and the Netherlands). Methods: We conducted a cross-sectional study using the 2007 Commonwealth Fund International Health Policy Survey data. The outcome was patient-reported error in the past 2 years. Possible predictors were studied using logistic regression. Results: Eleven thousand nine hundred and ten respondents were included in this analysis, of which 1291 respondents (11%) had experienced error. Poor coordination of care was a shared concern of all seven countries (adjusted odds ratios (ORs) ranged from 2.1 (95% CI: 1.3–3.5) to 3.0 (95% CI: 2.1–4.5)). Cost-related barriers to medical services/medicines was also a predictor in six countries [ORs ranged from 1.9 (95% CI: 1.5–2.6) to 2.6 (95% CI: 1.5–4.6)]. Other common risk factors across countries included seeing multiple specialists, multiple chronic conditions, hospitalisation and multiple emergency room visits. Cross-country heterogeneity in contributing factors included age and specific chronic condition. Number of medications, number of doctor visits, household income and education level were not associated with error in most countries. Conclusion: Poor coordination of care is a key risk factor in all seven countries. Cost-related barriers were also associated with an increased likelihood of error. The major challenge for all countries for error prevention is better communication among multiple healthcare providers and more structured organisation of care across healthcare settings.

What's known
Medication errors are a serious safety concern. Drug-related problems are a substantial burden on healthcare resources and about 5–8% of hospital admissions are related to adverse drug events.

What's new
This study compared factors associated with errors in Australia, Canada, Germany, the Netherlands, New Zealand, the United Kingdom and the United States. We found poor coordination of care as a key risk factor of error in all seven countries. Despite years of patient safety research and intervention, better communication among multiple healthcare providers and more structured organisation of care remain the major challenge for all countries for error prevention.

Introduction

The safety of medication use has important public health implications affecting mortality and morbidity (1,2). Medication errors are a serious safety concern that have existed for as long as medications have been available to patients. Medication errors are broadly defined as any error occurring in the medication use process (e.g., prescribing, dispensing or administration of an inappropriate or incorrect drug or dose), irrespective of whether such errors lead to adverse consequences (3). They are a major cause of adverse drug events and one of the most preventable causes of patient injury (4,5). Adverse drug events are common in most clinical settings; it has been reported that incidence rates were 6.5% of adult inpatients (6) and 27.4% of adult outpatients (7).

Previous systematic reviews have shown that 5–8% of hospital admissions are related to adverse drug events (8,9). Other consequences of adverse drug events include prolonged hospital stay, additional resource utilisation, time away from work, and poor patient satisfaction (10,11). Drug-related problems are also a substantial burden on healthcare resources (1,2,12). A US study estimated that the cost of drug-related problems in the ambulatory setting exceeded US$177 billion in the year 2000 (13). A recent review of Australian studies indicated that 2–3% of hospital admissions are medication related, which translate to an estimated cost of AUS$660 million per year (14).

All countries are faced with the challenge of findings ways to reduce medical or medication errors. An international survey of adults conducted by the Commonwealth Fund in 2007 showed that errors were common in seven countries (15). Australia and the United States had the highest patient self-reported rates of medication error (15% and 13%, respectively,) while the United Kingdom, the Netherlands and...
Germany had the lowest rates (9%) (15). The aim of this study was to compare the factors associated with medication errors across several developed countries.

**Methods**

**Data source**

We used existing data from the 2007 Commonwealth Fund International Health Policy Survey. The 2007 survey focused on four issues, access, primary care, coordination and safety, to understand adults’ health care experiences in seven countries: Australia, Canada, New Zealand (NZ), the United Kingdom (UK), the United States (US), Germany and the Netherlands (15). The sampling strategy, data collection protocols and descriptive data from this survey have been documented elsewhere (15). In brief, telephone survey was administered by Harris Interactive and their international affiliates. Random-digit dialling selected households and adults aged 18 or older were randomly selected within each household for participation. Survey responses were weighted to reflect the distribution of the adult population in each country; weights included age, sex, region, education, race and ethnicity (for the US) (15). The margin of sampling error was approximately ±2% for the US and Canada and ±3% for the other countries at the 95% confidence level (15). This international survey has provided data for similar comparative analysis on issues such as cost-related prescription non-adherence (16).

**Outcome measure**

The outcome measure, medication error/medical mistake, was based on responses to two questions in the survey: “In the past 2 years, have you ever been given the wrong medication or wrong dose by a doctor, nurse, hospital or pharmacist when filling/collecting a prescription at a pharmacy or while hospitalised?” and “Have you believed a medical mistake was made in your treatment or care in the past 2 years?” Using both questions, we created a binary outcome: ‘error = 1’ for respondents answering ‘yes’ to either or both questions, and ‘error = 0’ for those answering ‘no’ to both questions; each respondent contributed only once in the analyses. We combined medication and medical errors to create the dependent variable because they occurred at similar rates across countries (Table 1).

**Data analysis**

Possible predictors of error included: organisational factors, patient characteristics, clinical conditions and use of drugs and non-drug health services. Univariate analysis was undertaken to screen for potentially important variables to be included in the subsequent multivariate models. The independent variables examined included: age, sex, education level, household income, number of chronic conditions, number of emergency room visits in the past 2 years, number of medications taken by the respondent at the time of the interview, number of specialists seen in the past year and number of doctor visits in the past year. We also assessed binary variables that indicated whether the respondent had a hospitalisation in the past 2 years, cost-related barriers in the past year (that is, skipped doctor visit, medicine or laboratory/diagnostic test because of cost), a regular primary care physician or place of care, and whether the respondent had the following conditions: arthritis, heart disease, diabetes, asthma, chronic obstructive pulmonary disease, hypertension, depression or cancer. The variable ‘coordination problem’ was based on a positive response to either unavailable medical test results or medical records at the time of appointment, or duplicate tests (that is, doctor ordered a medical test that had already been done). Multivariate logistic regression models were fitted by including variables with a univariate association of p < 0.25. Separate analyses were conducted for each country. Odds ratios (ORs) and 95% confidence intervals (CI) were calculated for each variable.

We used t-test for continuous variables and chi-square test for categorical variables to compare participant characteristics among countries. p < 0.05 indicated statistically significant differences between countries (paired comparisons); no adjustment for multiple comparisons was made. Statistical analysis was performed with SAS (version 9.1.3, SAS Institute, Cary, NC).

**Results**

A total of 11,910 respondents were included in this analysis, of which 1291 respondents (11%) had experienced an error in the past 2 years. More than half of the respondents were women in all countries. The mean age ranged from 46.0 ± 17.1 years in Germany to 55.1 ± 15.0 years in the Netherlands. The vast majority of respondents had a regular doctor or place of care. In all countries except Germany, more than half of the respondents had at least one chronic illness with hypertension being the most prevalent condition (Table 1).

**Univariate analyses**

The proportions of respondents reporting experience of error were compared across different characteristics in each country (Table 2). Unadjusted ORs from univariate logistic regression models are shown in...
Table 1. Participant characteristics

|                  | AUS (N = 1009) | CAN (N = 3003 | NZ (N = 1000) | UK (N = 1434) | US (N = 2500) | GER (N = 1407) | NETH (N = 1557) |
|------------------|----------------|---------------|---------------|---------------|---------------|----------------|----------------|
| **Medication/medical error, N** |                |               |               |               |               |                |                |
| Medication error  | 127            | 293           | 109           | 122           | 314           | 133            | 193            |
| N (%)            | 75 (7.4)       | 172 (5.7)     | 59 (5.9)      | 75 (5.2)      | 174 (7.0)     | 73 (5.2)       | 124 (8.0)      |
| Medical error    | 86 (8.5)       | 191 (6.4)     | 79 (7.9)      | 76 (5.3)      | 204 (8.2)     | 85 (6.0)       | 99 (6.4)       |
| N (%)            |               |               |               |               |               |                |                |
| Female %         | 63.9           | 54.4*         | 61.0*         | 61.2*         | 62.3*         | 53.1*          | 59.2*          |
| Mean age (standard error) | 51.1 (16.3) | 49.5 (16.3)* | 48.5 (16.1) | 52.6 (17.1)* | 46.0 (17.1)* | 46.0 (17.1)* | 55.1 (15.0)* |
| **Income level %** |                |               |               |               |               |                |                |
| Below average    | 30.4           | 27.9*,†       | 25.0*,†       | 29.2*,†       | 31.0*,†,‡,§   | 33.0*,†,‡,§,*  | 31.0*,†,‡,§,** |
| Average          | 18.8           | 20.0          | 16.9          | 25.0          | 18.7          | 21.8           | 16.4           |
| Above average    | 46.5           | 45.0          | 55.0          | 45.2          | 38.0          | 46.0           |                |
| **Education level %** |            |               |               |               |               |                |                |
| High school or less | 47.7          | 29.1*         | 44.0*,†       | 46.1*,†,‡,§   | 31.3*,†,‡,§   | 61.8*,†,‡,§,*  | 67.7*,†,‡,§,**,* |
| College          | 18.6           | 40.7          | 26.2          | 24.4          | 32.6          | 24.2           | 25.6           |
| Higher than college | 33.0          | 29.1          | 28.7          | 23.4          | 35.5          | 11.6           | 6.4            |
| Had care coordination problem % | 15.6 | 14.5          | 12.3*         | 11.7*,†       | 22.3*,†,‡,§   | 19.2*,†,‡,§,*  | 12.5*,§,**,** |
| Had cost-related barriers % | 21.0 | 11.0*         | 21.4†         | 6.7*,†,‡,§    | 32.1*,†,‡,§,* | 20.7*,†,‡,§,*  | 5.0*,†,‡,§,**,* |
| Has regular doctor or place of care % | 96.6 | 92.3*         | 96.1†         | 97.3†         | 92.9*,†,‡,§,* | 94.5*,†,‡,§,*  | 99.9*,†,‡,§,**,* |
| **No. of specialists seen %** |                |               |               |               |               |                |                |
| None             | 44.5           | 53.8*         | 57.3*         | 58.2*,†       | 44.4*,†,‡,§   | 30.4*,†,‡,§,*  | 36.1*,†,‡,§,**,* |
| 1                | 24.9           | 24.5          | 22.7          | 18.9          | 23.6          | 24.9           | 27.6           |
| 2 or more        | 30.3           | 20.9          | 19.8          | 20.4          | 30.5          | 44.5           | 36.0           |
| Had hospitalisation | 26.1          | 16.1*         | 22.0*,†       | 19.3*,†       | 22.2*,†,‡,§   | 26.4*,†,‡,§,*  | 27.6*,†,‡,§,†  |
| Visited emergency room % | 28.7 | 38.1*         | 24.9†         | 25.9†         | 34.2*,†,‡,§,* | 20.6*,†,‡,§,*  | 18.7*,†,‡,§,*  |
| **Medication use %** |                |               |               |               |               |                |                |
| None             | 41.3           | 42.3          | 50.8*,†       | 40.2*,†,‡,§   | 32.2*,†,‡,§,* | 52.6*,†,‡,§,*  | 27.4*,†,‡,§,**,* |
| 1–3              | 40.5           | 39.4          | 36.2          | 35.6          | 38.8          | 34.0           | 40.9           |
| 4 or more        | 18.0           | 17.6          | 12.7          | 21.6          | 28.2          | 12.9           | 31.5           |
| Has chronic condition % | 60.7 | 50.0*         | 53.6*         | 50.4*         | 60.9†,‡,§     | 44.9†,‡,§,*    | 68.3†,‡,§,**,*  |

*Different to Australia (p < 0.05 for paired comparison); †Different to Canada; ‡Different to New Zealand; §Different to United Kingdom; *Different to the United States; **Different to Germany.

Table 3. Poor coordination of care and cost-related barriers were associated with higher rates of patient-reported error in all countries. Several patient-level factors were also associated with higher rates of error, including: hospitalisation, multiple chronic conditions, and higher utilisation of healthcare services (i.e., numbers of specialists seen, emergency room services, doctor visits and medications). There were no strong associations between the likelihood of error and age, income or education level in most countries.

Multivariate analyses

Organisational factors

Organisational factors were significantly associated with the likelihood of error and were common across countries. Poor coordination of care was a shared concern of all countries and increased the likelihood of error by 2- to 3-fold after adjusting for other covariates (Table 4). Respondents who had had cost-related barriers to medical services/medicines in the past 12 months were more likely to experience an error in all countries except the Netherlands [ORs ranged from 1.9 (95% CI: 1.5–2.6; p < 0.001) to 2.6 (95% CI: 1.5–4.6; p = 0.001)].

Patient-level factors

Seeing two or more specialists increased the likelihood of error by 1.6- to 3-fold in Australia, Canada, the US and the Netherlands (Table 4). In these four countries, having had a hospitalisation in the past 2 years also increased the likelihood of error by 1.4- to 2-fold. Having had two or more visits to emergency room in the last 2 years was associated with error in Australia, NZ, the US, Germany and
the Netherlands (increased likelihood by 1.7- to nearly 4-fold). Further, having two or more chronic illnesses increased the likelihood of error by 2-fold in Canada, the UK, and the US.

Cross-country heterogeneity in contributing factors included age and specific chronic condition. Depression was a predictor of error in the US (OR 1.7, 95% CI 1.3–2.3; p < 0.001), the UK (OR 1.7, 95% CI 1.3–2.3; p < 0.001), and the Netherlands (increased likelihood by 1.7- to nearly 4-fold). Further, having two or more chronic illnesses increased the likelihood of error by 2-fold in Canada, the UK, and the US.

Table 2 Percentages of adults reporting medication/medical error with selected characteristics in each country

| Organisational factors | AUS (N=127) | CAN (N=293) | NZ (N=109) | UK (N=122) | US (N=314) | GER (N=133) | NETH (N=193) |
|------------------------|-------------|-------------|------------|------------|------------|-------------|-------------|
| Care coordination problem No | 28.0 | 24.2 | 27.6 | 23.21 | 26.5 | 20.4 | 34.5 |
| Cost-related barriers Yes | 24.1 | 21.5 | 20.6 | 25.5 | 20.9 | 16.8 | 29.5 |
| No | 9.5 | 8.3 | 8.3 | 7.4 | 8.7 | 7.5 | 11.5 |

| Patient-level factors | AUS (N=127) | CAN (N=293) | NZ (N=109) | UK (N=122) | US (N=314) | GER (N=133) | NETH (N=193) |
|------------------------|-------------|-------------|------------|------------|------------|-------------|-------------|
| No. of specialists seen None | 5.8 | 5.8 | 8.4 | 5.5 | 7.8 | 5.3 | 4.4 |
| One | 11.6 | 12.0 | 7.5 | 11.1 | 11.4 | 9.1 | 11.6 |
| Two or more | 23.5 | 17.5 | 22.2 | 15.1 | 20.8 | 12.5 | 21.1 |
| Hospitalisation Yes | 24.7 | 21.6 | 20.6 | 13.7 | 23.2 | 15.6 | 24.0 |
| No | 8.3 | 7.5 | 8.2 | 7.3 | 9.6 | 7.3 | 8.0 |
| No. of emergency use None | 7.9 | 7.4 | 7.7 | 6.8 | 8.8 | 6.7 | 9.8 |
| One | 19.8 | 9.5 | 17.0 | 9.7 | 14.6 | 17.0 | 17.8 |
| Two or more | 31.0 | 17.7 | 26.7 | 18.5 | 26.9 | 31.2 | 36.2 |
| No. of doctor visits None | 12.2 | 6.0 | 6.7 | 3.9 | 8.9 | 4.1 | 7.3 |
| One | 7.3 | 6.0 | 6.4 | 6.6 | 7.1 | 7.4 | 7.3 |
| 2–4 | 7.7 | 9.4 | 10.5 | 8.4 | 11.2 | 9.9 | 12.2 |
| Five or more | 19.7 | 17.3 | 18.3 | 13.7 | 23.6 | 14.5 | 20.9 |
| No. of medications None | 9.3 | 7.5 | 8.8 | 6.2 | 7.3 | 7.6 | 5.1 |
| 1–3 | 13.9 | 10.1 | 11.6 | 9.2 | 12.3 | 11.1 | 11.9 |
| Four or more | 17.0 | 14.6 | 17.3 | 12.0 | 19.2 | 12.6 | 19.4 |
| No. of chronic conditions† None | 8.8 | 5.8 | 7.6 | 5.5 | 7.6 | 7.9* | 5.7 |
| One | 10.3 | 9.9 | 12.1 | 9.1 | 12.5 | 10.6 | 10.8 |
| Two or more | 18.5 | 16.1 | 16.3 | 14.2 | 18.3 | 12.4 | 19.3 |
| Age group 18–29 | 18.1 | 15.0 | 14.3* | 12.4* | 18.2 | 12.9* | 15.4* |
| 30–49 | 12.7 | 9.6 | 12.9 | 8.8 | 12.8 | 8.8 | 12.1 |
| 50–64 | 11.0 | 9.4 | 8.3 | 7.2 | 12.5 | 7.7 | 13.1 |
| 65 and over | 12.0 | 7.3 | 8.0 | 8.2 | 9.9 | 9.2 | 11.5 |
| Income level Below average | 14.7* | 10.7* | 11.2* | 10.5* | 14.3* | 9.7* | 14.3* |
| Average | 11.2 | 10.4 | 12.6 | 6.7 | 11.4 | 7.9 | 8.9 |
| Above average | 11.9 | 8.9 | 10.2 | 9.0 | 12.0 | 10.5 | 12.9 |
| Education level High school or less | 10.8* | 7.9* | 10.7* | 7.4 | 12.7* | 8.3* | 10.8 |
| College | 15.4 | 11.4 | 10.7 | 8.3 | 12.3 | 12.4 | 17.0 |
| Higher than college | 13.8 | 9.5 | 11.5 | 12.5 | 13.0 | 9.8 | 10.0 |

*Non-significant (p > 0.05) chi-square pair wise comparisons; †Respondents diagnosed with any of the following conditions: arthritis, heart disease, diabetes, asthma, chronic obstructive pulmonary disease, hypertension, depression or cancer.
CI 1.1–2.8; p = 0.05) and Germany (OR 1.8, 95% CI 1.0–3.2; p = 0.04). In Canada, diabetes and cancer were significantly associated with error (OR 1.6, 95% CI 1.0–2.4, p = 0.04 and OR 1.7, 95% CI 1.1–2.6, p = 0.02, respectively). Respondents of young age (18–29 years old) were more likely to experience error in Canada (OR 1.6, 95% CI 1.0–2.4; p < 0.001) and the Netherlands (OR 2.5, 95% CI 1.1–5.9; p = 0.04) when compared with those of older age (65 years and over).

Number of doctor visits, number of medications that the respondent was taking at the time of interview, household income and educational level were not significantly associated with the likelihood of error.

### Table 3: Impact of factors on likelihood of medication/medical error in adults in each country (univariate analysis results)

|                      | AUS (N = 1009) | CAN (N = 3003) | NZ (N = 1000) | UK (N = 1434) | US (N = 2500) | GER (N = 1407) | NETH (N = 1557) |
|----------------------|----------------|---------------|--------------|---------------|--------------|--------------|---------------|
|                      | OR 95% CI      | OR 95% CI     | OR 95% CI    | OR 95% CI     | OR 95% CI    | OR 95% CI    | OR 95% CI     |
| **Organisational factors** |                |               |              |               |              |              |               |
| Poor care coordination | 3.6 2.4–5.5 | 4.0 3.1–5.3 | 4.1 2.6–6.5 | 4.3 2.8–6.5 | 3.8 3.0–4.9 | 3.5 2.4–5.0 | 5.2 3.7–7.3 |
| Cost-related barriers  | 3.0 2.0–4.5 | 3.0 2.2–4.1 | 2.9 1.9–4.4 | 4.3 2.6–7.2 | 2.8 2.2–3.5 | 2.5 1.7–3.6 | 3.2 1.9–5.4 |
| **Patient-level factors** |                |               |              |               |              |              |               |
| Hospitalisation       | 3.6 2.5–5.3 | 3.4 2.6–4.4 | 2.9 1.9–4.4 | 2.0 1.3–3.0 | 2.8 2.2–3.6 | 2.4 1.6–3.4 | 3.6 2.7–5.0 |
| No. of specialists seen | None*         |                |              |               |              |              |               |
| One                   | 2.1 1.2–3.7 | 2.2 1.6–3.0 | 0.9 0.5–1.6 | 2.1 1.3–3.4 | 1.5 1.1–2.1 | 1.8 1.0–3.1 | 2.9 1.7–4.7 |
| Two or more           | 5.0 3.1–8.1 | 3.4 2.6–4.6 | 3.1 2.0–4.9 | 3.0 2.0–4.7 | 3.1 2.4–4.1 | 2.5 1.6–4.1 | 5.8 3.7–9.1 |
| No. of emergency use  | None*         |                |              |               |              |              |               |
| One                   | 2.9 1.8–4.5 | 1.3 0.9–1.8 | 2.4 1.5–4.0 | 1.5 0.9–2.5 | 1.8 1.3–2.4 | 2.8 1.9–4.3 | 2.0 1.3–3.0 |
| Two or more           | 5.2 3.2–8.4 | 2.7 2.1–3.6 | 4.3 2.5–7.4 | 3.1 2.0–5.0 | 3.8 2.8–5.1 | 6.3 3.5–11.3 | 5.2 3.3–8.3 |
| No. of doctor visits  | None*         |                |              |               |              |              |               |
| One                   | 0.6 0.2–1.4 | 1.0 0.6–1.6 | 1.0 0.4–2.2 | 1.8 0.8–3.9 | 0.8 0.5–1.3 | 1.9 0.8–4.1 | 1.0 0.5–1.9 |
| 2–4                   | 0.6 0.3–1.2 | 1.6 1.1–2.4 | 1.6 0.8–3.3 | 2.3 1.2–4.5 | 1.3 0.9–1.9 | 2.6 1.3–5.1 | 1.8 1.1–2.9 |
| Five or more          | 1.8 1.0–3.3 | 3.3 2.2–5.0 | 3.1 1.6–6.3 | 4.0 2.2–7.7 | 3.2 2.1–4.7 | 4.0 2.0–8.1 | 3.3 2.0–5.6 |
| No. of medications    | None*         |                |              |               |              |              |               |
| One                   | 1.6 1.0–2.4 | 1.4 1.1–1.9 | 1.4 0.9–2.1 | 1.5 1.0–2.4 | 1.8 1.3–2.5 | 1.5 1.0–2.2 | 2.5 1.5–4.1 |
| Four or more          | 2.0 1.2–3.3 | 2.1 1.5–2.9 | 2.2 1.2–3.8 | 2.0 1.3–3.3 | 3.0 2.2–4.2 | 1.7 1.0–2.9 | 4.5 2.7–7.2 |
| No. of chronic conditions† | None*      |                |              |               |              |              |               |
| One                   | 1.2 0.7–2.0 | 1.8 1.3–2.5 | 1.7 1.0–2.7 | 1.7 1.1–2.8 | 1.7 1.2–2.4 | 1.4 0.9–2.1 | 2.0 1.2–3.2 |
| Two or more           | 2.4 1.5–3.6 | 3.1 2.3–4.1 | 2.4 1.4–3.9 | 2.8 1.8–4.4 | 2.7 2.0–3.6 | 1.7 1.1–2.6 | 4.0 2.6–6.1 |
| Age group             |                |               |              |               |              |              |               |
| 18–29                 | 1.6 0.9–3.1 | 2.2 1.5–3.4 | 1.9 0.9–4.0 | 1.6 0.9–2.9 | 2.0 1.3–3.1 | 1.5 0.8–2.5 | 1.4 0.7–2.9 |
| 30–49                 | 1.1 0.6–1.8 | 1.3 0.9–1.9 | 1.7 0.9–3.2 | 1.1 0.7–1.7 | 1.3 0.9–1.9 | 0.9 0.6–1.6 | 1.1 0.7–1.6 |
| 50–64                 | 0.9 0.5–1.6 | 1.3 0.9–1.9 | 1.0 0.5–2.1 | 0.9 0.5–1.5 | 1.3 0.9–1.8 | 0.8 0.5–1.5 | 1.2 0.8–1.7 |
| 65 and over           | –              | –              | –              | –              | –              | –              | –              |
| Income level          |                |               |              |               |              |              |               |
| Below average         | 1.3 0.8–1.9 | 1.2 0.9–1.6 | 1.1 0.7–1.8 | 1.2 0.8–1.9 | 1.2 0.9–1.6 | 0.9 0.6–1.4 | 1.1 0.8–1.6 |
| Average               | 0.9 0.6–1.5 | 1.2 0.9–1.6 | 1.3 0.8–2.1 | 0.7 0.5–1.2 | 0.9 0.7–1.3 | 0.7 0.5–1.2 | 0.7 0.4–1.0 |
| Above average*        | –              | –              | –              | –              | –              | –              | –              |
| Education level       |                |               |              |               |              |              |               |
| High school or less   | 0.8 0.5–1.2 | 0.8 0.6–1.1 | 0.9 0.6–1.5 | 0.6 0.4–0.9 | 1.0 0.7–1.3 | 0.8 0.5–1.5 | 1.1 0.6–2.2 |
| College               | 1.1 0.7–1.9 | 1.2 0.9–1.6 | 0.9 0.5–1.6 | 0.6 0.4–1.0 | 0.9 0.7–1.3 | 1.3 0.7–2.4 | 1.8 0.9–3.7 |
| Higher than college*  | –              | –              | –              | –              | –              | –              | –              |

*Reference group; †Respondents diagnosed with any of the following conditions: arthritis, heart disease, diabetes, asthma, chronic obstructive pulmonary disease, hypertension, depression or cancer.
To our knowledge, this was the first comparison of error predictors across several developed countries. The current study highlights that poor coordination of care increases the likelihood of medication error and this is a shared concern of all seven countries. Further, cost-related barriers to medical services/medicines contributed to error in six of the seven countries. Patient factors identified included seeing two or more specialists, hospitalisation in the past 2 years, multiple visits to emergency room in the previous 2 years and multiple chronic illnesses. Depression was also a risk factor in the UK, the US.

| Table 4 | Impact of factors on likelihood of medication/medical error in adults in each country (multivariate analysis results) |
|---------|------------------------------------------------------------------------------------------------------------------|
|         | AUS (N = 1009)                                                                                                   |
|         | CAN (N = 3003)                                                                                                   |
|         | NZ (N = 1000)                                                                                                    |
|         | UK (N = 1434)                                                                                                    |
|         | US (N = 2500)                                                                                                    |
|         | GER (N = 1407)                                                                                                   |
|         | NETH (N = 1557)                                                                                                  |
| Organisational factors | | | | | | | |
| Poor care coordination | 2.1 1.3–3.5 2.5 1.9–3.3 2.6 1.5–4.4 2.6 1.6–4.2 2.4 1.8–3.1 2.6 1.8–3.9 3.0 2.1–4.5 |
| Cost-related barriers | 2.0 1.3–3.2 1.9 1.4–2.6 2.1 1.3–3.4 2.6 1.5–4.6 1.9 1.5–2.6 1.9 1.3–2.9 1.5 0.8–2.7 |
| Patient-level factors | | | | | | | |
| Hospitalisation | 1.7 1.1–2.8 2.1 1.6–2.9 1.6 1.0–2.7 1.1 0.7–1.8 1.4 1.0–1.9 1.4 0.9–2.2 1.9 1.3–2.8 |
| No. of specialists seen | | | | | | | |
| None* | – – – – – – – – – – – – – – |
| One | 1.7 0.9–3.0 1.6 1.1–2.2 0.6 0.3–1.2 1.6 0.9–2.6 1.2 0.9–1.7 1.2 0.7–2.1 1.8 1.1–3.1 |
| Two or more | 2.8 1.6–4.9 1.6 1.1–2.2 1.5 0.9–2.7 1.6 0.9–2.7 1.6 1.2–2.3 1.3 0.7–2.2 1.9 1.1–3.2 |
| No. of emergency use | | | | | | | |
| None* | – – – – – – – – – – – – – – |
| One | 1.9 1.1–3.2 0.9 0.7–1.4 1.8 1.0–3.2 1.0 0.6–1.9 1.2 0.9–1.7 1.9 1.2–3.1 1.3 0.8–2.0 |
| Two or more | 2.6 1.4–4.6 1.3 0.9–1.7 2.2 1.1–4.2 1.6 0.9–2.7 1.7 1.2–2.4 3.6 1.9–7.0 2.4 1.4–4.1 |
| No. of doctor visits | | | | | | | |
| None* | – – – – – – – – – – – – – – |
| 1 | 0.7 0.3–1.9 1.0 0.6–1.7 0.9 0.4–2.2 1.6 0.7–3.7 0.9 0.5–1.5 1.5 0.7–3.5 1.0 0.5–1.9 |
| 2–4 | 0.5 0.3–1.1 1.3 0.8–2.0 1.2 0.6–2.6 1.5 0.7–3.0 1.1 0.7–1.6 1.8 0.9–3.7 1.1 0.6–1.9 |
| Five or more | 1.1 0.5–2.2 1.6 1.0–2.5 1.4 0.6–3.3 1.6 0.8–3.5 1.4 0.9–2.3 2.0 0.9–4.5 1.3 0.7–2.4 |
| No. of medications | | | | | | | |
| None* | – – – – – – – – – – – – – – |
| 1–3 | 1.2 0.7–2.1 1.0 0.7–1.3 1.1 0.6–1.9 1.1 0.7–2.0 1.3 0.9–1.9 1.2 0.7–2.0 1.7 1.0–2.9 |
| Four or more | 1.0 0.4–2.1 0.9 0.6–1.4 1.5 0.6–3.4 1.0 0.5–1.9 1.5 1.0–2.3 1.2 0.6–2.6 1.9 1.0–3.6 |
| No. of chronic conditions‡ | | | | | | | |
| None* | – – – – – – – – – – – – – – |
| One | 0.8 0.5–1.6 1.6 1.1–2.3 1.3 0.8–2.3 1.4 0.8–2.4 1.3 0.9–1.9 1.2 0.7–1.9 1.2 0.7–2.1 |
| Two or more | 1.4 0.7–2.5 2.4 1.6–3.4 1.8 0.9–3.4 2.1 1.1–4.0 1.6 1.1–2.4 1.4 0.7–2.6 1.6 0.9–2.9 |
| Age group | | | | | | | |
| 18–29 | 1.5 0.7–3.6 3.5 2.1–5.9 2.0 0.8–5.1 1.3 0.6–2.8 2.7 1.6–4.5 1.6 0.8–3.3 2.5 1.1–5.9 |
| 30–49 | 1.1 0.6–2.2 1.9 1.2–2.9 2.4 1.1–5.5 1.1 0.6–2.0 1.5 1.0–2.3 1.1 0.6–2.1 1.5 0.9–2.4 |
| 50–64 | 0.9 0.5–1.6 1.4 0.9–2.2 1.4 0.6–3.1 0.8 0.5–1.4 1.3 0.9–1.9 0.9 0.5–1.6 1.2 0.8–1.8 |
| 65 and over* | – – – – – – – – – – – – – – |
| Income level | | | | | | | |
| Below average | 0.9 0.5–1.5 1.1 0.8–1.5 0.7 0.4–1.2 1.2 0.7–2.0 0.8 0.6–1.1 0.9 0.6–1.4 1.0 0.6–1.4 |
| Average | 0.8 0.4–1.4 1.2 0.9–1.7 1.2 0.7–2.2 0.9 0.5–1.5 0.9 0.6–1.3 0.7 0.4–1.1 0.7 0.4–1.1 |
| Above average* | – – – – – – – – – – – – – – |
| Education level | | | | | | | |
| High school or less | 0.7 0.4–1.1 0.7 0.5–1.0 0.9 0.5–1.5 0.5 0.3–0.9 0.8 0.6–1.1 0.8 0.5–1.5 1.0 0.5–2.1 |
| College | 1.2 0.7–2.1 1.0 0.7–1.4 1.0 0.5–1.7 0.5 0.3–0.9 0.8 0.6–1.1 1.3 0.7–2.4 1.6 0.8–3.6 |
| Higher than college* | – – – – – – – – – – – – – – |

p < 0.05 (bold); *Reference group; †Adjusted odds ratios; ‡Respondents diagnosed with any of the following conditions: arthritis, heart disease, diabetes, asthma, chronic obstructive pulmonary disease, hypertension, depression or cancer.
and Germany while diabetes and cancer were predictors in Canada. Patients with multiple chronic conditions or mental health concerns often receive care from multiple clinicians and have complex medication regimens. Such patients are at increased risks of hospitalisation, adverse drug events and complications, particularly if effective care coordination is lacking (17).

It is recognised that communication problems exist between specialists and primary care physicians, the laboratory and physicians’ offices, hospital-based and office-based physicians, the hospital and physicians’ offices and nursing homes and physicians’ offices (18). Missing clinical information during physician visits is a frequent problem and is likely to result in either a delay in care or a duplicative medical service (19–21). These breakdowns in professional communication may adversely affect patient care as well as decrease efficiency and increase healthcare expenditure (18–21). Studies have shown that less than half of primary care physicians are provided with information about discharge medications and plans for their recently hospitalised patients (22,23). Further, there is an association between discontinuity of care from the inpatient to the outpatient setting and the prevalence of medical errors (24). Our findings and the earlier research suggest that improved communication between healthcare providers, including that between hospital-based physicians and outpatient primary care providers, may reduce medical errors.

An interesting finding of the present study was that despite universal healthcare coverage in all countries except Canada and the US, a notable proportion of patients had cost-related barriers to medical services/medicines in the past year and this factor was strongly associated with the likelihood of medication errors. Cost-related barriers are possibly related to the actual range of coverage of specific medical services, diagnostic and laboratory tests and medications in each country. By skipping a laboratory/diagnostic test or doctor visit, important clinical information may not have been obtained and this may have contributed to error.

Our analysis also shows cross-country variation in risk factors of error and these were related to the characteristics of patients (namely, specific chronic condition and age). Previous studies reported that the number of concomitant medications is an independent predictor of adverse drug events (25,26). We did not detect a strong association between the number of medications and the likelihood of error after controlling for other covariates. However, interpretation of this result is limited by the small sample sizes and the cross-sectional nature of the study because there might have been a substantial time interval between the occurrence of the patient-reported error (any time within the past 2 years) and the measurement of medication count (at the time of the survey). In most countries, age was not a predictor. In countries where age was significantly associated with error, respondents of younger age had a higher likelihood of experiencing errors than those of older age, possibly because this subgroup was less likely to have a regular place of care.

Several limitations should be noted. First, as a result of the cross-sectional design, we have shown associations but we cannot confirm any causal relationships. Second, interpretation of the results is limited by the small sample sizes. Third, we could not discern whether the reported medical errors were directly related to medication use, however, errors in drug treatments and therapeutic mishaps are common events among medical errors (27). Fourth, the binary dependent variable definition likely underestimates the proportion of adults who did not experience a medication error because the variable is not explicitly linked to medication usage (i.e. technically adults who did not receive any prescriptions for medications during the reference period should not be included in the ‘no error’ group). Fifth, our study was based on patient-reported error, which is vulnerable to recall bias and underestimation attributable to bias of detection and reporting of errors. Further, this study is a secondary analysis of existing data sourced from an international survey. Therefore, our analysis and findings are restricted to the range of information and level of details collected by the original survey as safety was only one of the four themes explored. Notably, the setting (inpatient or outpatient) of where errors occurred was not elicited in the survey, and poor coordination of care was defined on the basis of surrogates (missing clinical information or duplicative medical test). The determinants examined in this study were also based on patient self-report perspective (rather than from the perspective of healthcare systems or clinicians). Finally, the weights adjusted final samples to the expected population distribution but likely under-represent the most socially disadvantaged individuals and those in remote areas, particularly those without phones, speaking other languages or whose health limited their participation (15). Possible sources of non-sampling error of the original survey include non-response bias, cultural differences in question interpretation and interviewer effects (28).

This comparative analysis highlights poor coordination of care and cost-related barriers to medical
services/medicines as key risk factors associated with error in most countries. Factors relating to a greater complexity of patient management were also important predictors. Our findings have important implications for policy-makers and clinicians. With respect to potential preventive measures, coordination of care is the most important starting point for changes in the organisational aspect of patient management. There is also an urgent need for better communication among multiple healthcare providers and effective transfer of medical information, to improve patient safety.

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Author contribution

CL and ER designed the study; CL conducted the analyses; CL and ER contributed to the interpretation of the data; CL drafted and reviewed the manuscript; ER reviewed the manuscript. All authors read and approved the final manuscript.

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