Hosp Pharm 2013;48(11):922–930

www.hospital-pharmacy.com
doi: 10.1310/hpj4811-922

Original Article

Evaluation of a Dedicated Pharmacist Staffing Model in the Medical Intensive Care Unit

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Abstract

Purpose: Published studies have shown that pharmacists on medical rounds reduce the incidence of preventable adverse drug events (ADEs). However, the impact of a dedicated pharmacist who provides consistent patient care in a critical care unit remains to be evaluated.

Objective: To determine the impact of a pharmacist who is permanently assigned to the medical intensive care unit (MICU) on the incidence of preventable ADEs, drug charges, and length of stay (LOS) in the MICU.

Design: A randomized, experimental versus historical control group design was used. Preventable ADEs were identified and validated by 2 pharmacists and a critical care physician. Information about MICU drug charges and LOS were obtained from the hospital administrative database.

Results: The intervention group had fewer occurrences of ADEs (10 ADEs/1,000 patient days) when compared to the control group (28 ADEs/1,000 patient days) at a significance level of .03. No significant differences were found between the 2 groups in MICU drug charges and LOS. The vast majority of the 596 documented recommended interventions (99%) were accepted by the medical team. Nutrition monitoring, medication indicated but not prescribed, and dosage modification were the top 3 problems identified by the pharmacist.

Conclusion: The addition of a dedicated critical care pharmacist to the MICU medical team improves the safe use of medication. The services of a dedicated critical care pharmacist should be expanded to include weekend hours to ensure the benefits of improved medication safety.

Key Words—adverse drug events, medication safety, pharmacist, staffing model

Hosp Pharm—*2013;48(11):922–930*

Adverse drug events (ADEs), injuries resulting from the administration of a drug, levy serious costs on health care institutions and patients by requiring further complex care, prolonged lengths of hospital stay, and increased risk of death. The incidence rates of ADEs range from 10 ADEs per 1,000 patient days, of which 56% were preventable,[1] to 6.5 ADEs per 100 patient admissions, of which 28% of all ADEs were preventable.[2] The cost of ADEs is estimated to be $2,000 per admission.[2] This amount varies by institution and is a conservative estimate for 2013. Systems-related factors, such as drug ordering and administration processes, are likely contributing factors to preventable ADEs rather than patient-related characteristics.[2] Specifically, drug information not available to physicians at the time of ordering medication was found to account for 29% of errors.[3] The availability of up-to-date drug information, including guidelines and recommendations about monitoring, doses, drug interactions, and duration of therapy, is critical when prescribing medication.

One way to reduce ADEs is to place experts where processes occur in the system.[4] Clinical pharmacists

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are trained drug specialists who can provide information to physicians and nurses about drug dosing, interactions, contraindications, and monitoring that can improve safe drug use. Leape and colleagues[5] evaluated the impact of adding a pharmacist to an intensive care unit (ICU) rounding team. The addition of the pharmacist reduced the incidence of preventable ADEs by 66% and by 72% when compared to a usual care (control) group. Pharmacists provided 398 interventions during the 9-month study. These interventions included correcting or clarifying medication orders (45%) and providing drug information (25%). The physicians accepted virtually all of the recommendations (99%) provided by the pharmacists.[5] These findings were replicated by Kucukarslan and colleagues[6] who found a 78% reduction in preventable ADEs when pharmacists rounded with the medical team in the general medicine unit. This study also found that patients with an ADE had an increased length of stay (LOS) by an average of 1.4 days. In a 2007 survey of 885 hospital pharmacies, 23% had pharmacists participating in medical rounds.[7]

Kaushal and colleagues[8] studied the impact of pharmacists on reducing serious medication errors by extending their services beyond the rounding team. A pre-post control group (standard care) versus intervention study design was used to evaluate the impact of 2 pharmacist staffing models. The first staffing model was tested in the ICU. A full-time pharmacist in the ICU pharmacist model participated in the rounding process and oversaw the medication dispensing, storage, and administration processes. A rounding pharmacist (part-time) staffing model was used in the general medicine and the general surgery units. The study demonstrated that the full-time pharmacist model significantly decreased the number of serious medication errors and intercepted near misses. The general medicine and general surgery units with the part-time rounding pharmacist did not have the same reduction in medication errors as the full-time pharmacist model. Thus, the staffing function is important for improved medication safety.

The benefit of having pharmacists on staff during the rounding process and overseeing other aspects of medication use on reducing medication errors has been shown. It has yet to be determined whether assigning the same pharmacist to a medical unit to improve patient care has the same effect. A dedicated pharmacist is scheduled to care for patients in the same patient care unit or pod over a specified time period. This pharmacist is able to establish a team relationship with the nursing staff and the medical team. Scheduling the same pharmacist in the same patient care unit allows for continuity of care over time. Scheduling multiple pharmacists in a patient care unit may result in delays in care or missed opportunities for clinical interventions, as a pharmacist who is new to the unit has to learn and assess patient cases before becoming actively involved.

The purpose of our study was to compare the impact of having a dedicated clinical pharmacist in the medical intensive care unit (MICU) to the standard clinical pharmacist model. The dedicated clinical pharmacist managed the care of the same patients over the 5-day work week (Monday through Friday). The pharmacist rounded with the medical staff, facilitated communication between the ICU staff and pharmacy (overseeing the dispensing and administration of medication), and provided support to nursing staff similar to the pharmacists in the study by Kaushal and colleagues.[8] The standard clinical pharmacist model provided the same full-time clinical pharmacist services; however, 2 to 3 clinical pharmacists rotated through various ICU areas. They were not scheduled in one particular area so they could not develop continuity of care during the week. Scheduling was based on the availability of clinical pharmacists to oversee the clinical services in all of the ICUs.

In our study, the primary hypothesis was as follows:

> The incidence of preventable ADEs will be significantly lower in MICU patients who receive dedicated critical care pharmacist services when compared to patients under the standard patient care model.

The secondary hypotheses were as follows:

> The drug charges will be significantly less for MICU patients who receive dedicated critical care pharmacist services when compared to patients under the standard patient care model.
>
> The LOS will be significantly less for MICU patients who receive dedicated critical care pharmacist services when compared to patients under the standard patient care model.

MATERIALS AND METHODS

This study used a prospective–retrospective group comparison design to evaluate the impact of having a dedicated pharmacist in an MICU. The patient data were obtained retrospectively for both control and intervention groups. However, the pharmacist activity or intervention data were collected prospectively. The study site was a large acute care teaching hospital (more than 500 beds) serving a large urban population. The

impact of the dedicated critical care pharmacist was evaluated by comparing the outcomes of patients who received dedicated clinical pharmacy services (prospective evaluation) to those of patients who were cared for under the standard care model (retrospective evaluation). The intervention and the standard care groups were evaluated in the same MICU, but at different points in time. This allowed all factors to remain constant with exception of the pharmacist staffing model.

The standard care (control) model rotated clinical pharmacists through several ICUs. The scheduling was based on staffing requirements. For example, a clinical pharmacist could be scheduled in the MICU for 2 days and then be scheduled for 3 days in the cardiac ICU. Critical care pharmacists were scheduled to provide clinical services 1 month out of every 3 months in the ICUs and to enter orders and oversee the dispensing of medication. Clinical pharmacy services for the ICUs were provided Monday through Friday from 7:00 a.m. until 3:00 p.m. The dedicated pharmacist staffing model scheduled one clinical pharmacist to one specific ICU (thus the same patients) over the 5-day work week. The ICU pharmacists had on average 2 to 3 years ICU experience but did not have specialty residency training.

The intervention and control groups in this study had the same critical care pharmacist rounding with the MICU medical team and following the patients consistently on weekdays. The co-investigator (K.C.) was the dedicated clinical pharmacist in the intervention group. She has a PharmD with 2 years of postgraduate residency including critical care. The control group patients were randomly selected from patients who were admitted to the MICU between February 1, 2003, and July 31, 2003. After a 1-month washout period, the dedicated clinical pharmacist model was implemented in the same MICU. Data were collected from randomly selected patients who were admitted to the ICU between September 1, 2003, and November 30, 2003. There were 75 patients selected for each group, which was the same sample size used by Leape et al.[5]

The main outcome, preventable ADEs, was defined as an undesirable reaction to medication that could have been avoided with appropriate drug selection, dosing, monitoring, or management. Co-investigators (M.P. and M.M.) independently reviewed the patient records to identify preventable ADEs. The medical records were paper documents. Each page was reviewed to identify preventable ADEs. The co-investigators were clinical pharmacist specialists with at least 10 years of critical care experience. A critical care physician (L.S.) reviewed the preventable ADEs to determine the likelihood that these events were related to the medication. Any identified incident that was considered a likely preventable ADE was documented. Secondary outcomes were patient LOS and drug costs in the MICU. These data were retrieved from the administrative database. Patient demographics and the number of comorbidities were collected in the medical records. The Acute Physiology and Chronic Health Evaluation II (APACHE II) score was calculated for each patient by the co-investigators (M.P. and M.M) to compare both groups at baseline. The APACHE II is a classification system used to categorize disease severity in ICU settings.[9] The groups were compared using these measures to determine whether any other possible source of variance could affect the results.

The clinical pharmacist in the intervention group identified potential drug therapy problems and documented interventions. Potential drug therapy problems were classified as inappropriate indications, therapeutic duplications, medications indicated but not prescribed, nonformulary agents, patient allergy, dosage modifications required, inappropriate route/methods of administration used, monitoring modifications required, inappropriate duration of therapy/therapy completed, significant drug interactions identified, adverse drug reactions (ADRs) identified, potential ADRs avoided, patient education required, drug information needed by physician or nurse, systems errors, nutrition monitoring needed, and other problems not otherwise specified. This study combined and modified problem subgroups that were used in previous studies by Leape et al[5] and Kucukarslan et al.[6]

The pharmacist interventions included notifying a physician; writing, changing, or discontinuing medication orders; educating the patient; or documenting an ADR. It was noted whether the pharmacist's interventions were accepted or rejected.

The main study hypothesis was tested using chi-square analysis ($P < .05$). The secondary hypotheses were tested using analysis of variance ($P < .05$). SPSS 14.0 for Windows (IBM SPSS, Armonk, NY) was used in the statistical analysis.

RESULTS

Data were collected for 55 intervention patients and 71 control patients. The difference in the number of patients between the 2 groups was due to data collection problems in accessing medical records, circulating data collection forms, and collecting them from the researchers in a timely manner. Each reviewer received the medical records and documented the ADEs or stated "none" if none occurred. Each reviewer saw

Table 1. Comparison of baseline characteristics of ICU patients in dedicated pharmacist group versus and control group

	Dedicated pharmacist group (n=55)	Control group (n=71)	*P*
Mean (SD) age, years	60.2 (15)	56.6 (20)	.27[a]
Mean (SD) APACHE II	17.6 (8)	19.1 (8.5)	.31[a]
Race, %			
African American	56	68	.07[b]
White	35	32	
Hispanic	7		
Other	2		
Gender, %			
Female	47	48	
Male	53	52	.95[b]
Mean (SD) comorbidities	4.11 (1.74)	3.49 (1.67)	.04[a]

Note: ICU = intensive care unit.
[a]Significant at $P < .05$ for analysis of variance statistical analysis.
[b]Significant at $P < .05$ for chi-square statistical analysis.

all the completed data sheets. Using the published ADE rate of 44% in ICU patients,[5] the statistical power needed to detect a 66% reduction in errors between groups with a sample size of 50 is 90% (Type 1 error < 0.05). So the statistical power of the data analysis is acceptable.

The demographic variables and APACHE II scores demonstrated no significant differences between the 2 groups as shown in **Table 1**. However, there was a statistically significant difference between the 2 groups in terms of the number of comorbidities. The number of comorbidities and group designations were tested as confounding factors through bivariate logistical regression analysis to control for variance in the probability of the occurrence of an ADE. Neither the number of comorbidities nor group designation was shown to account for a statistical impact upon the probability of the occurrence of an ADE, with *P* values of .577 and .751, respectively. Also, the APACHE II scores were not significantly different, indicating that these 2 groups were comparable with respect to potential morbidity.

The initial analysis found no statistically significant difference in the incidence of preventable ADEs between the 2 groups (**Table 2**). Upon examination of the dates of ADE occurrence, we found that 4 of the 7 ADEs occurred when the pharmacist was not scheduled (weekend or holiday). A similar examination in

Table 2. Comparison of measurable outcomes in ICU patients in dedicated pharmacist group versus control group

Outcomes	Dedicated pharmacist group (n = 55)	Control group (n = 71)	*P*
Mean (SD) drug charges, $	3,362 (5,770)	3,225 (4,827)	.88[a]
Mean (SD) ICU LOS, days	5.25 (5.50)	6.60 (10.10)	.34[a]
Total LOS per group, days	307	475	
Preventable ADE incidents, n			
All	7	14	.40[b]
Excluding weekend/holiday	3	13	.03
ADEs per 1,000 patient days			
All	23	31	
Excluding weekend/holiday	10	28	

Note: ADE = adverse drug event; ICU = intensive care unit; LOS = length of stay.
[a]Significance level (*P* value) for analysis of variance statistical analysis.
[b]Significance level (*P* value) for chi-square statistical analysis.

the control group indicated 1 out of the 13 ADEs occurred during the weekend. Thus, the preventable ADE rates were recalculated. Accounting for the pharmacists' schedules (no services were provided on the weekend), there was a statistically significant difference in preventable ADEs ($P = .03$).

ADEs are described in the **Appendix**. Most of the ADEs in the control group were associated with the inappropriate use of diuretics, which resulted in electrolyte imbalance or metabolic alkalosis. There were 2 cases in the control group that involved patients with renal dysfunction.

There were no significant differences between the 2 groups with respect to ICU drug charges and the ICU LOS (**Table 2**). The intervention group had slightly greater drug charges than the control group.

The types and frequencies of drug therapy problems identified by the dedicated critical care pharmacist are listed in **Table 3**. The most frequent problems were issues of nutrition monitoring (14%), medication indicated but not prescribed (12%), and dosage modification required (12%). Approximately 1 out of 10 problems was a systems-related problem, including the need to clarify medication orders and to address medication dispensing–related problems (ie, missing doses). Another 1 out of 10 problems was a request for drug-therapy related information from the nursing and the medical staff. Seven percent of the problems were preventable ADEs, which corresponds to our primary outcome measure.

Once a problem was identified, the critical care pharmacist documented the resulting actions. **Table 4** lists the types and frequencies of specific of actions, with a total of 596 actions. The action type that occurred in the highest frequency involved notifying a physician or other health care professionals; this action occurred 280 times (47%). Only 6 recommendations offered by the critical care pharmacist were not accepted, reflecting a 99% intervention acceptance rate.

DISCUSSION

Our results showed that a dedicated clinical pharmacist in the MICU can reduce the number of preventable ADEs through identifying and resolving medication-related and

Table 3. Types of problems identified by the critical care pharmacist

Identified problem type	No. of occurrences	%
Nutrition monitoring	49	14
Medication indicated but not prescribed	42	12
Dosage modification required	41	12
Follow-up assessment of aminoglycoside/vancomycin regimen needed	38	11
Identification of systems error	36	10
Drug therapy information requested (MD/RN)	35	10
Potential adverse reaction avoided	25	7
Initial assessment of aminoglycoside/vancomycin regimen needed	19	5
Inappropriate duration of therapy/therapy completed	18	5
Inappropriate route/method of administration used	16	5
Monitoring modification required	10	3
Adverse drug reaction identified	4	1
Inappropriate indication	3	0.9
Therapeutic duplication	3	0.9
Nonformulary agent changed to formulary agent	3	0.9
Significant drug interaction identified	3	0.9
Patient allergy to prescribed drug	2	0.6
Nonformulary medication prescribed	1	0.2
Other problem (specify)		0.9
Intubation	1	
Noncompliance	1	
Antibiotic change	1	
Total	348	

Table 4. Types of actions performed by the critical care pharmacist

Action type	No. of occurrences	%
Physician or other health provider notified	280	47
Medication order written, changed, or discontinued	177	30
Action documented in patient's chart (general memo or multidisciplinary education sheet)	78	13
Other order written, changed, or discontinued	51	9
Recommendation made but not accepted	6	1
Adverse drug reaction documented	3	1
Patient educated	1	<1
Total	596	

systems-related problems and providing drug-related information. A dedicated staff person provided consistent care for patients and established a working relationship with other health care professionals on the team. Virtually all recommendations made by the dedicated pharmacist were accepted by the attending physician. Systems-related problems that have historically created conflict between pharmacy and nursing staff, such as missing orders or clarifying orders, were addressed quickly. By avoiding delays in care and medication errors, the dedicated pharmacist contributed to improved quality of care, which was demonstrated by a decrease in LOS. Although not statistically significant, the LOS for patients in the pharmacist intervention group was 2 days less on average compared to patients in the control group.

The dedicated pharmacist addressed 299 drug-related problems and provided 49 nutrition-monitoring services for 55 patients in the MICU. During the study time period, The Joint Commission on the Accreditation of Healthcare Organizations had mandated that all inpatients receive initial nutrition and hydration assessments along with continual nutrition follow-ups. Because the study site's nutrition service had recently experienced a staff reduction, the responsibility for nutrition assessment and monitoring was transferred to clinical pharmacists.

The second most common pharmacist intervention was the addition of a medication to a patient's regimen where it was indicated but not prescribed. This may, in part, explain why drug charges, on average, were higher for the intervention group than for the control group. The pharmacist serving in the intervention model stated that medications for deep vein thrombosis prophylaxis or stress ulcer prophylaxis were frequently recommended, followed by antibiotics, blood pressure medications, and long-acting insulin.

An unexpected and interesting finding was that 4 of the 7 ADEs that occurred in the pharmacist intervention group occurred during the weekend. The impact of weekend staffing on patient mortality has been investigated in other studies. Cram et al[10] found a statistically significant increased risk of mortality for patients who were admitted to major teaching hospitals on a weekend (13% increased likelihood of mortality) versus nonteaching hospitals (3% increased likelihood of mortality). Bell and Redelmeier[11] analyzed Canadian hospitalization data and found significantly greater mortality rates for serious medical conditions (ie, ruptured aortic aneurysms) and for conditions associated with greater mortality for patients who were admitted during the weekend when controlling for patient demographics and severity of condition. Thus, the maintenance of patient quality of care on the weekend depends on staffing the hospital unit with qualified and sufficient number of personnel.

Out of all patients with ADE data, 7 in the pharmacist group and 13 in the control group had preventable ADEs. Of these 20 ADEs, 7 were due to a diuretic, such as furosemide, spironlactone, and hydrochlorothiazide; these patients typically experienced ADEs resulting in metabolic alkalosis and electrolyte imbalances. Results of this study suggest that clinical pharmacists play a vital role in preventing ADEs in patients receiving this class of medications.

Since the study, the hospital site implemented the dedicated pharmacist model in the ICUs. Clinical pharmacists in the ICU manage the same patients during the week. However, the model has not changed for the weekend. Clinical pharmacists are available in the ICU during the weekend, but they manage more patients than during the week. Advancements in information technology have been incorporated in the medication management system, allowing clinical pharmacists to enter medication orders while attending to clinical responsibilities.

Limitations

The results of this study have limited generalizability. The study was conducted at one large nonprofit

acute care hospital located in southeastern Michigan and may not represent other institutions. In addition, this study only analyzed patients admitted to the MICU, which further limits its applicability to patients not admitted to similar medical units or to those with less severe reasons for hospital admittance.

The collected data were from 2 separate time phases. Changes in standard of care or hospital policy may have been implemented since study initiation and could have affected the results. This bias was assumed to be limited due to the short time interval between the control group and the pharmacist intervention group. Also, the accuracy of the measures is dependent on the quality of documented information in the medical records. Both groups were subject to the same degree of documentation accuracy, thus it was assumed that the possibility of this type of error was negligible. A more critical source of error is the number of irretrievable charts in the intervention group.

Finally, feedback from nursing staff and physicians can only be reported anecdotally. A physician and nurse satisfaction report would have quantified the benefits they received from having a dedicated clinical pharmacist on their unit.

Conclusions

A randomized standard care control versus a dedicated pharmacist intervention study design was used to compare the number of preventable ADEs. We found significantly fewer preventable ADEs in the pharmacist intervention group, after accounting for weekend occurrences. We noted that weekend staffing is important to maintain the quality of care offered during the 5-day work week. This weekend effect has been noted in other publications. The dedicated pharmacist was able to provide consistent and useful drug therapy–related services to the medical staff in the MICU. These services included monitoring nutrition, ordering medications that were indicated but not previously ordered, providing drug therapy–related information, resolving medication systems-related problems, and identifying preventable ADEs.

ACKNOWLEDGMENTS

Financial support/disclosures: This study was supported by the Department of Pharmacy Services, Henry Ford Hospital. The study site was Henry Ford Hospital, 2799 W. Grand Boulevard, Detroit, MI 48202.

Conflict of interest: The authors declare no conflict of interest.

Ethics statement: All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed.

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APPENDIX
Description of Specific Adverse Drug Events Identified During Study

Patient description, age/race/sex	Drug/agent	Reaction	Contributing factor
Pharmacist group			
72/AA/male	Amiodarone, dose too low	Atrial fibrillation	Hypokalemia
55/AA/female	Furosemide	Hypernatremia	Diabetes insipidus, secondary to lithium toxicity (upon admission), furosemide given for CHF; occurred on a Saturday
51/AA/male	Furosemide	Hypokalemia	Identified on first day of ICU[b]; pharmacist not on schedule
74/White/female	Labetolol, dose too high	Hypotension (initial BP 200/165 fell to 100/68)	Stroke patient
18/H/male	Prednisone + dexamethasone	Serum glucose 254	Insulin protocol not ordered; occurred Sunday
75/AA/female	Sodium bicarbonate	Respiratory alkalosis	Plasma pH 7.57; chronic renal failure
57/AA/male	Sulfamethoxazole/trimethoprim; interaction with captopril	Increased potassium acidosis	Occurred Sunday
Control group			
50/W/female	Atenolol	Hypotension	Should have discontinued atenolol
70/AA/male	Colchicines	Hypotension	ESRD
18/AA/female	Dextrose IVF	Exacerbated condition	Diabetic ketoacidosis
79/AA/female	Digoxin	AV blockade	Acute renal failure
81/W/male	Furosemide	Hypokalemia	
82/AA/male	Furosemide	Metabolic alkalosis, hypotension	
54/AA/male	Furosemide (failed to discontinue)	Contraction alkalosis, hypotension	
81/AA/female	Flumazenil (inappropriate indication)	Increased risk of seizure	CVA
78/AA/male	Furosemide + prednisone	Contraction alkalosis (over diuresis)	
21/AA/female	IVF with no potassium	Hypokalemia, anion gap	
63/AA/female	(1) Lisinopril	(1) Hyperkalemia	Adverse drug events 2-4 occurred on Sunday; muscle weakness was due to malnutrition
	(2) HCTZ	(2) Hypotension, metabolic alkalosis	
	(3) Morphine	(3) Constipation	
	(4) Prednisone	(4) Thrush	
	(5) Prednisone	(5) Muscle weakness	
	(6) Diazepam + lisinopril	(6) Hypotension	

(continued)

(CONT.)

Patient description, age/race/sex	Drug/agent	Reaction	Contributing factor
55/W/male	Metoprolol	Bradycardia	Orders written without BP and heart rate parameters for holding dose; occurred Saturday
47/W/male	Spironolactone	Hyperkalemia	Acute renal failure
83/AA/female	Stress ulcer prophylaxis not ordered	Stress ulcer	

Note: AA = African American; AV = atrioventricular; BP = blood pressure; CHF = congestive heart failure; CVA = cerebrovascular accident; ESRD = end-stage renal disease; H = Hispanic; HCTZ = hydrochlorothiazide; ICU = intensive care unit; IVF = intravenous fluid; W = White.

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informatics during their professional training to introduce them to the technology they will use upon graduation and to give them the skills that will allow them to critically evaluate the advantages and shortcomings of the technology they use. The inclusion of pharmacists in CPOE implementation teams is common, but many of these pharmacists have no substantive exposure to these systems and are poorly equipped to evaluate them or address the needs of other users as they arise. Because pharmacists often use components of these systems that no other health care professional sees, it is vital that pharmacists understand and can critically evaluate those components and the systems as a whole. Although several professional organizations have recognized the need for informatics to be a portion of the PharmD curriculum, this area of study has not yet caught up to the technology, and pharmacists are still entering the workforce ill prepared for the technological challenges that await them. If we do not catch the technology wave now, we may find ourselves washed away by it in the future.

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