Related Works

**Lifestyle and Health Impact:**

One-handed textual entry on mobile phones has been studied extensively by HCI researchers. This area of study is driven by a wide variety of use cases, ranging from improving typing accessibility for those with disabilities to the increasing prevalence of texting while walking. We carry mobile phones around with us all the time, and as a result, interacting with it while on-the-go has become a daily routine \cite{clawson}. According to a recent study in 2022, 26\% of people always use a mobile phone while walking on the street, 43\% sometimes do, 28\% occasionally do, and only 3\% do not \cite{Frej}. While texting on-the-go, individuals must multi-task. They must not only maintain awareness of their surroundings but also be focused on interacting with the mobile device that is in motion. As a result, the combination of multitasking and interacting with a often shaken device, impairs the user’s typing performance and accuracy significantly \cite{clawson}.

One common breakdown discussed in the contextual inquiries was the physical discomfort of texting with one hand. This motivated the team to look into the effects of mobile phone use on an individual's health. We found a decade-long study that monitored the effects of mobile phone use on people's physical health. From 2011 to 2020, the study reported that there have been phone-related injuries ranging from 3,389 to 7320 annually. These injuries included wrists and hand pain, ruptured tendons, and enlarged median nerves. The age group most affected were between the ages of 11 to 30, making up 48.6% of the injuries **(CITE)**. One common reason for these injuries were due to overuse of the person’s thumb. People who frequently text with one hand do not have the flexibility or the reach to access keys on the other side of the hand. Thus, the users will have to overstrain their thumbs and wrists which puts them at risk for the injuries mentioned above.

**Previous Solutions:**

Past research has been done studying how different types of layouts can be used to optimize typing accuracy and speed for one-handed textual entry for mobile devices. Some of the existing one-handed keyboard layouts include curved keyboards as well as a user-adaptable standard QWERTY keyboard \cite{Kunpeng}. The CAK (Circularly Arced Keyboard), as shown in Figure~\ref{fig:CAK\_Layout}, equally divides each key by 90 degrees into a quarter-circle layout \cite{Leung}. It is intended to be operated with a single thumb and training time to become familiar with the CAK layout is minimal. The idea behind it is to allow the user’s thumb to be able to reach every single key without having to reposition the phone. However, studies have shown that the improvement to speed and accuracy is not that significant on top of the added learning curve to being familiar with the layout \cite{Leung}.

The user-adaptable keyboard layout allows the user to resize the standard QWERTY layout to their desired size as well as shift it to the left or right side of the screen, depending on their typing hand. This layout has a much lower learning curve and is significantly better received by users \cite{Kunpeng}.

There have also been existing studies and concepts that focus more on one-handed typing on physical keyboards instead of virtual keyboards on mobile devices. One of these existing technologies is the Half-QWERTY keyboard. The HALF-QWERTY keyboard has half the keys of a standard keyboard. To type the characters that are not present on the half keyboard, the user must press the spacebar and the mirror half of the keyboard will be mapped onto the keys. Studies show that there is an increased error rate as well as decreased speed \cite{Matias}.

HCI researchers have also completely redesigned the keyboard from the standard QWERTY to specifically support one handed text entry. One example is the 5-key chording device. As the name suggests, this new keyboard only consists of 5 buttons. The 31 different combinations produced from the 5 buttons allow mappings for each 26 letters, backspace, space, comma, period and enter to a combination. The researchers conducted experiments to test the learnability and usability of this new “keyboard.” While the participants made a significant amount of mistakes in their first attempts, the average number of errors decreased exponentially with each subsequent round. Furthermore, similar trends occurred with respect to speed. The wpm (words per minute) increased at a constant rate from 4.2 wpm to 15.2 wpm \cite{Tarniceriu}.

Although there are already existing technologies and keyboard layouts to address the need of one-handed typing on mobile phones, most of these existing technologies have a steep learning curve and reduce the accuracy and speed of typing. In addition, most HCI research is focused on the English alphabet and does not look closely into other writing systems, such as Chinese or the Cyrillic alphabet. As a result, the effects of one-handed textual entry for the majority of the human population is severely understudied. Furthermore, there has been no research that we are aware of that studies the effects of switching keyboard languages on speed and accuracy. This is important as bilingualism among the general population is on the increase. Lastly, most HCI research is also focused on letter entry and does not focus on the entry of symbols such as \% or !, and emojis. Entries of these symbols and emojis typically require the user to switch to a different keyboard, which may not be standardized over all keyboards interfaces, as opposed to the standard QWERTY layout.

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An Epidemiological Study of Cell Phone-Related Injuries of the Hand and Wrist Reported in United States Emergency Departments From 2011 to 2020,

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Abstract: Purpose

Increasing ownership and use of mobile phones has been recently linked to reports of hand and wrist pain from overuse, as well as more serious injuries related to distracted behaviors, such as falls and texting while driving. We describe the epidemiology of hand and wrist injuries presenting to US emergency departments from 2011 to 2020, which were associated with cell phone use using the Consumer Product Safety Commission’s National Electronic Injury Surveillance System.

Methods

The National Electronic Injury Surveillance System database was queried for treatment records from 2011 through to 2020 for all cell phone-related injuries of the lower arm, wrist, hand, and fingers. Using parameters provided by the National Electronic Injury Surveillance System database, there were 1,213 unique cases, yielding a total weighted estimate of 50,487 national cases presenting to emergency departments in the United States.

Results

Between 2011 and 2020, the weighted estimate of annual cell phone-related injuries ranged from 3,389 to 7,320 cases. Falls were the most common cause of injury, accounting for 29.8% of estimated cases. The most common types of injuries were lacerations (22.3%). The national estimate of cell phone-related injury was the highest in the age range of 11–20 years (26.4%), followed by 21–30 years (22.2%). Women were affected more frequently than men (59.6% vs 40.4%).

Conclusions

Upper extremity injuries related to cell phone use represent an increasing burden of disease to the US healthcare system. Raising awareness regarding cell phone-related injuries and in-home fall-prevention strategies, especially among elderly individuals, should be considered as means of decreasing the number of such injuries. Strategies for decreasing the burden of cell phone−related injuries occurring as a result of falls among teenagers and young adults should focus on minimizing distractions while using a cell phone. Limitations of the study include inaccuracies related to probability-weighted case estimation and limitations in reporting injuries.

Clinical relevance

Knowledge of the burden of upper extremities injuries associated with this common handheld device can help to both raise awareness of this issue, as well as to potentially inform injury-prevention strategies.

Keywords: Cell phone; Epidemiology; Hand; Hand trauma; Wrist