NICE National Institute for Health and Care Excellence

NICE advice

Mersey Burns for calculating fluid resuscitation volume when managing burns

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Summary

Mersey Burns is an app that helps to determine fluid resuscitation requirements for patients with burn injuries. It calculates the percentage area of the body affected by the burn and uses this to calculate the fluid resuscitation requirements. The available evidence is of limited quantity and quality. Two studies comparing Mersey Burns with paper chart and calculator-based methods, using clinical simulation data, suggested that the app determined fluid requirements more quickly. In 1 of the studies, medical students with no previous experience of burns management calculated fluid requirements using Mersey Burns and a paper and calculator-based method. The study reported significantly better accuracy for fluid volumes calculated using the Mersey Burns app compared with the paper-based method, although the findings may be subject to bias. Mersey Burns is available on several commonly used platforms and is free to download.

Product summary and likely place in therapy

- Mersey Burns is a software application (app) that calculates the total burn surface area (TBSA) in patients with burn injuries, as well as the volume of resuscitation fluids needed using the Parkland formula and background fluid requirements.
- It can be used in any setting but may be particularly useful in acute care such as emergency departments.
- It would replace traditional paper chart and calculator methods for estimating TBSA and calculating fluid requirements.
- If adopted, Mersey Burns could facilitate early management by non-burns specialists but would not otherwise alter burn management.

Effectiveness and safety

- The available evidence is limited in quantity and quality.
- Two studies were identified that used Mersey Burns in clinical simulations. The studies included 96 patients and a total of 414 calculations. Both studies suggested that using Mersey Burns resulted in faster calculation of fluid resuscitation requirements than estimating TBSA using the Lund and Browder paper chart with a calculator. However, 1 of the studies concluded that this is unlikely to be clinically significant in practice.
- One study found that inexperienced users calculated 8- and 16-hour fluid volumes with 100% accuracy using the Mersey Burns app compared with 62% and 64% respectively for the paper chart and calculator methods. Accuracy was assessed by 2 of the study authors and may be subject to bias. The study also highlighted the uncertainty in current methods used to calculate background fluid requirements in children.
- One study found that users preferred Mersey Burns to traditional paper chart and calculator methods.

Technical and patient factors

- Mersey Burns can be used for patients of any age. It makes adjustments for infants and children, on the basis that their head makes up a larger proportion of their body compared with adults.
- Mersey Burns is intended for use only by qualified medical professionals, but they do not need to have specialist experience in burn injury management. It can be used if

the patient is not present as long as the TBSA is known.

Cost and resource use

- The Mersey Burn app is free to download and use.
- No published evidence was identified on the resource implications of using the technology.

Introduction

Burn injuries can result from exposure to heat (including flames, hot liquids or objects; referred to as thermal burns), chemicals, electricity or radiation. The International Burn Injury Database recorded that 81,181 patients attended specialist burn services for assessment and admission in England and Wales between 2003 and 2011 (Stylianou et al. 2014).

Appropriate burn injury assessment and management is critical to ensure the best outcomes for patients. The severity of a burn injury is assessed by its depth, extent and location, the patient's age and the presence of other injuries or diseases. The extent of a burn is expressed as the percentage of the body surface area affected. This is referred to as the total burn surface area (TBSA). There are several standard methods for estimating TBSA: the Lund and Browder chart; Wallace's Rule of Nines; and the Rule of Palm (Hettiaratchy and Papini, 2004).

The Lund and Browder method is a paper chart with an outline of a person divided into several regions, each represented by a number. The chart is shaded to show the burned area and the TBSA is calculated by adding the numbers for each affected region. In babies and children, the head and legs make up different proportions of the body surface area, so the chart includes age-related numbers for these areas (Hettiaratchy and Papini, 2004). Wallace's Rule of Nines estimates the affected body surface area of an adult using multiples of 9 representing different areas of the body. Different calculations are used for children and infants. The Rule of Palm assumes that the palm (including the fingers) of the person who is burned is about 1% of the body. This can be used to calculate the body surface area burned. However, all of these methods are reported to provide inaccurate estimates of TBSA (Giretzlehner et al. 2013; Parvizi et al. 2014).

One of the major complications associated with severe burns is fluid loss, so replacing lost fluids (fluid resuscitation) is important. The amount of resuscitation fluid needed in the first 24 hours after the burn injury is based on the TBSA and the person's body weight. There are several formulae to calculate fluid requirements; the most commonly used one in the UK is the Parkland formula, devised at the Parkland Memorial Hospital in the USA (Baker et al. 2007). Half of the fluid needed is infused intravenously over the first 8 hours after the burn injury, and the second half is given over the next 16 hours. Children may need additional intravenous background (maintenance) fluids, which also need to be calculated.

Because several calculations are needed to devise a fluid resuscitation protocol, there is potential for error. Inaccuracies in TBSA estimates can have a profound impact on fluid resuscitation outcome, morbidity and mortality (Parvizi et al. 2014). As appropriate fluid resuscitation is essential, physiological parameters are also monitored to assess the patient's response and to help avoid complications. Giving too much fluid can give rise to cardiac failure, an increased risk of infectious complications, acute respiratory distress syndrome, abdominal compartment syndrome, and even death. Giving too little fluid can lead to hypovolaemic shock, organ failure and systemic inflammatory response syndrome (Luo et al. 2015).

Technology overview

This briefing describes the regulated use of the technology for the indication specified, in the setting described, and with any other specific equipment referred to. It is the responsibility of healthcare professionals to check the regulatory status of any intended use of the technology in other indications and settings.

About the technology

CE marking

Medicapps was awarded a class I CE mark for Mersey Burns for use with iPad, iPhone, iPod touch, Android devices, BlackBerry PlayBook and HTML5-compatible browsers in September 2011.

The Medicines and Healthcare Products Regulatory Agency has issued guidance that explains what medical device software applications are and how this type of technology is regulated.

Description

Mersey Burns is a mobile application (app) for use by clinicians in managing burn injuries caused by any means. It has been developed to calculate the percentage of the body surface area affected and the amount of replacement fluid required intravenously (referred to in the app as the fluid prescription) in the first 24 hours to ensure the patient remains haemodynamically stable. It also calculates the additional intravenous background (or maintenance) fluids needed by children younger than 16 years.

The app calculates the TBSA using the Lund and Browder method, the resuscitation fluids using the Parkland formula and background fluids for children. The mobile device versions of the app allow details about the burn and the fluid prescription to be emailed, for example to the receiving hospital.

Mersey Burns is free to download and requires iOS 6.0 or later, Android OS v2.3.3 or later, BlackBerry PlayBook or a HTML5-compatible browsers.

There have been 8 versions of Mersey Burns:

- 1.0.0 – First release.
- 1.1.0 – New icon, fixed the location of the turn button on the iPad in landscape orientation, fixed the '1 hr ago' and '4 hrs ago' buttons when they cross midnight, fixed warning text on startup, added shake to clear, changed clear to also reset age, weight, time and fluid rate, lowered minimum iOS version to 4.0 from 5.0.
- 1.2.0 – Made the user's manual available offline within the app, added a German language translation.
- 1.3.0 – Added warning about weights more 30% different to the estimate, added warning about simple erythema, new disclaimer agreement added, added automated testing, and described testing procedures in the manual, switched weight estimation formula to be 3×age+7, instead of 3×age+3, fixed a bug that meant changing the age reset the burn area if it was set manually, estimated weights now rounds to 5 kg in the same way as the manual user interface.
- 1.4.0 – Added support for retina displays and the iPhone 5, refreshed manual, reduced from 10,000 to 5,000 automatic tests to allow for slower devices.
- 1.5.0 – Released Android version, released HTML5 version, released PlayBook version,

there was no release of this version on iOS.

- 1.5.1 – iOS bug fixes, there was no release of this version on Android, HTML or Playbook.
- 1.6.0 – Switched to an all-integer code path for calculations for better reproducibility and testability, added 3 ml fluids option, support for iOS 7.
- 1.6.2 – New information governance wording in email.

On opening the app, the device screen shows a diagram of the front of a person's body. Regions of the body are shown by dividing lines. A diagram of the back of the body is displayed by tapping on the 'turn' button. Scrolling up and down allows the full body to be seen. These diagrams are used for people of both sexes and all ages. Areas affected by the burn can be 'drawn' on the diagram by selecting the 'draw' button, and highlighting the relevant area. Both full and partial thickness burns can be drawn. Buttons allow the user to partially erase or clear the burn area. The TBSA is calculated as the burn is being drawn on the diagram and displays in a label on the screen. Alternatively, if the percentage area is already known, it can be added by tapping the burn area label and selecting the appropriate percentage in 1% increments. A pop-up message advises the user not to include simple erythema.

The user also enters the patient's age and weight and the time of the burn injury. The default setting is for an adult weighing 60 kg with a burn occurring 5 minutes earlier. The age can be set using the 'birthday cake' button. This allows the selection of a specific age for those under 18 years, or 'adult' for those 18 years and over. An average weight for age can be selected, or the patient's weight can be entered using the 'scales' button. Weight measurements are in 1 kg increments up to 30 kg and in 5 kg increments thereafter. The time of the burn injury is set using the 'clock' button.

When details have been entered, the 'fluid bag' button should be tapped. The recommended intravenous fluid prescription is displayed, separated into the first 8 hours after the burn injury and the next 16 hours. For children younger than 16 years, the rate of intravenous background fluids needed is also displayed. The user can select from 2 ml/hour, 3 ml/hour and 4 ml/hour infusion rates depending on the clinical assessment. The manufacturer's instructions for use recommend that calculated values should always be checked manually and that clinical judgement should be applied.

The mobile device version of the app can email details about the burn and the fluid prescription if the user presses the 'envelope' button. The app itself does not allow patient identifiers to be entered or stored, but these can be added manually to the text of the email. Emails are marked as 'medical in confidence'. The app includes (from version 1.6.2) an information governance warning that person-identifiable information must only be sent and received by NHS.net email accounts.

The app is validated each time it starts. A battery of 5000 test cases are run, as if the data has been entered manually. The results of these calculations are compared with the test case solutions stored in the app. If there is a difference between the results, the app will not run to avoid a risk to patient safety.

Setting and intended use

The Mersey Burns app would be used in any healthcare setting, both in and out of hospital, but it may be particularly useful in acute care settings such as emergency departments. The app is intended for use by qualified medical professionals, with or without specialist experience in burns injury management. It can be used if the patient is not present as long as the TBSA and other details are available.

Current NHS options

Superficial (minor) burns and scalds are generally managed in primary care. More severe, complex burns may need to be treated in specialist departments.

There are no guidelines about when to refer someone presenting with a burn injury in primary care to an emergency department. This is also noted in the NICE clinical knowledge summary on burns and scalds. The Joint Royal Colleges Ambulance Liaison Committee Guideline Development Group (JRCALC) has produced the UK Ambulance Services Clinical Practice Guidelines (2013) for paramedics, which includes guidance on assessing and managing burns and scalds in adults and children. The National Network for Burn Care provides guidance for primary and secondary care providers on when to refer to specialised burn care services (National Burn Care Referral Guidance, 2012).

NICE is not aware of any other CE-marked devices that have a similar function to the Mersey Burns app, although a review of smartphone applications related to burns (Wurzer et al. 2015) identified 13 calculator apps in the Google Play Store, of which 6 were free to download, and 21 calculator apps in Apple's App Store, of which 8 were free to download. None of these apps are CE marked.

Costs and use of the technology

Mersey Burns is available to download for free by anyone with an iPad, iPhone, iPod touch, Android device, BlackBerry PlayBook or HTML5-compatible web browsers. It does not require any consumables. Users should download any updates to the app when they become available. Network issues may limit access to the HTML version of Mersey Burns or delay the receipt of updates to the app.

The manufacturer states that Mersey Burns has been adopted by the Midlands Burns Operational Delivery Network (MB ODN), which serves about 20% of the population in England.

Likely place in therapy

Mersey Burns would be used to calculate fluid requirements for adults and children with recent burn injuries. Use of the device is not expected to change the current clinical pathway. It would replace the need for manual calculations using the Lund and Browder chart or other methods for estimating TBSA. It may also facilitate faster and more accurate fluid resuscitation calculations than manual calculations using the Parkland formula. The device would most likely be used in acute care settings and could also be used remotely, with the results emailed to the treating clinical team (in accordance with information governance arrangements).

Specialist commentator comments

Three specialist commentators stated that they had experience of using the Mersey Burns app, and 1 commentator said its use is encouraged in their department. The same commentator believed that Mersey Burns is relevant to all healthcare professionals in the burn care pathway. One specialist commentator indicated that a burns network is using Mersey Burns but no data were available to assess if there had been an impact on fluid resuscitation. Three specialist commentators agreed that Mersey Burns was useful and simple to use; most also felt that the app was quick to use.

One specialist commentator stated that many healthcare professionals have smartphones which they use to access an array of other health-related information. One specialist commentator stated that many clinicians prefer the app-based technology to traditional paper-based systems. Another suggested that the user manual should be more accessible when the app is being used, and should have clear links to the specific sections from every screen. Two specialist commentators noted that the email facility would be a useful way of supplementing a telephone referral or for discussion with specialist burns services.

One specialist commentator noted that there is no warning in the app about the importance of measuring a patient's weight accurately. The commentator also noted the importance of accurately estimating the burn size and that this was a benefit of Mersey Burns. Two specialist commentators noted that estimating TBSA is difficult and that variation can occur between healthcare professionals, with 1 specialist commentator suggesting that this can lead to inaccuracies in fluid calculations. One specialist commentator emphasised that Mersey Burns eliminates the need to do consecutive calculations that can be subject to human error, particularly when people are under pressure.

One specialist commentator noted that other factors such as intravenous cannula siting, catheterisation, recording of fluid and monitoring of cardiovascular state (measuring heart rate, urine output and blood pressure) must also be considered during fluid resuscitation. The commentator added that Mersey Burns does not alert the user to specific situations where caution is needed, for example, in elderly patients or patients with heart failure; or that discussion should take place with an experienced burns clinician if there is concern about a particular patient. The commentator also said that there is no option to account for fluids that have already been administered, and expressed concern about advice given in the app for burn injuries which may have happened 6 or more hours earlier. They stated that in such cases, Mersey Burns would advise giving large volumes of fluid in a short space of time, which could be potentially dangerous and would have to be balanced against the risk of developing abdominal compartment syndrome. The commentator suggested that it would be useful to have a warning in the app to highlight this, but that determining the threshold for this would need specialist input.

Equality considerations

NICE is committed to promoting equality, eliminating unlawful discrimination and fostering good relations between people with particular protected characteristics and others. In producing guidance, NICE aims to comply fully with all legal obligations to:

- promote race and disability equality and equality of opportunity between men and women

- eliminate unlawful discrimination on grounds of race, disability, age, sex, gender reassignment, marriage and civil partnership, pregnancy and maternity (including women post-delivery), sexual orientation, and religion or belief (these are protected characteristics under the Equality Act 2010).

The severity of a burn may be affected by a person's age and the presence of other injuries or disease. Age and disability are protected characteristics under the Equality Act 2010.

Evidence review

Clinical and technical evidence

Regulatory bodies

A search of the Medicines and Healthcare Products Regulatory Agency website revealed no manufacturer Field Safety Notices or Medical Device Alerts for this device. No reports of adverse events were identified from a search of the US Food and Drug Administration (FDA) database: Manufacturer and User Device Facility Experience (MAUDE).

Clinical evidence

Two full-text studies were identified which evaluated the validity of the Mersey Burns app (Barnes et al. 2015; Morris et al. 2014). Both studies involved patient simulations. A review of smartphone applications for burns including Mersey Burns was also identified (Wurzer et al. 2015).

Barnes et al. (2015) assessed the accuracy and speed of the Mersey Burns app to estimate TBSA compared with the Lund and Browder paper chart, a standard tool for estimating TBSA. They also studied the accuracy and speed of both methods to calculate a fluid resuscitation protocol. The paper describes 2 studies: a pilot study involving 20 clinicians (study 1) was used to inform the design of the main study involving 42 medical students (study 2). In the pilot study, clinicians (10 specialist trainees and consultants from plastic surgery and 10 from emergency departments) were shown a photograph of a child with a burn injury and asked to calculate the TBSA, and then devise a fluid resuscitation and background (maintenance) fluid protocol. A calculator and a Lund and Browder paper chart to estimate TBSA were provided. The method of calculating fluid requirements from TBSA was not stated. Several of the clinicians (8/20; 40%) were uncertain how to calculate background fluid requirements in children using the comparator method (not stated) and did not attempt to do this. Four of the 10 plastic surgery staff (grade ST2 to consultant) assessed the same burn with the Mersey Burns app. There were no significant differences in the TBSA, total fluid requirements, fluid rate or maintenance fluid requirements calculated using the Mersey Burns app and the comparator method. However, there was a significant difference in the between-subject variance between the Mersey Burns app and the paper chart and comparator fluid calculation method for total fluids ($p<0.05$) and maintenance fluids ($p<0.0001$), with the paper method showing greater variance.

In the main study reported in Barnes et al. (2015), 42 senior undergraduate medical students were given a 1-hour lecture on burns management and fluid resuscitation involving demonstrations of the Lund and Browder chart and the Mersey Burns app. The students were then given a prosthetic burn simulation with a mixed burn injury and were asked to calculate the TBSA and a fluid resuscitation protocol using both the Mersey Burns app and the Lund and Browder chart. Again, the comparator method of fluid calculation used with the Lund and Browder chart was not stated. Variations in TBSA calculations, time taken and the accuracy of fluid calculations were compared between the 2 methods. Fluid volumes calculated by each student were manually checked for accuracy by 2 of the authors of the paper and confirmed as either correct or incorrect. Measures including preference, speed and ease of use were also assessed using a questionnaire. No significant difference was observed for the TBSA value when the Mersey Burns app was compared with the paper chart, although the mean time to calculate the result was quicker with the Mersey Burns app (11.7±2.8 minutes for paper [range 6 to 17 minutes] and 4.6±1.2 minutes for the app [range 3 to 7 minutes], mean difference 7.1 [95% confidence interval [CI] 6.09 to 8.18]). The accuracy of the fluid calculation was considered to be correct in 100% of the cases using the Mersey Burns app for the first 8 hours and the following 16 hours of fluid resuscitation. This compared with fluid calculation accuracy for the paper chart in 62% of cases (26/42, 95% CI 0.33 [0.17 to 0.49]) for the first 8 hours and 64% of cases (27/42, 95% CI 0.33 [0.18 to 0.48]) for the following 16 hours. The total fluid volume for the full 24 hours was accurately calculated using the Mersey Burns app in 100% of cases, and in 81% of cases using the paper chart (95% CI 0.17 0.05 to 0.28). Students favoured the Mersey Burns app over the paper chart in the following categories: preference in emergency setting, confidence in output, accuracy, speed, ease of calculation, ease of overall use ($p<0.0001$) and shading ($p=0.0007$).

Morris et al. (2014) evaluated the accuracy and speed of the Mersey Burns app compared with the uBurn app (a similar app which has not been CE-marked) and a general-purpose electronic calculator for calculating fluid requirements using the Parkland formula. Thirty four participants of various clinical grades and specialties were provided with randomly generated simulated clinical data and asked to calculate fluid requirements using the electronic calculator, the Mersey Burns app and the uBurn app. All patients were from a regional burns unit and had previous experience of calculations using the Parkland formula. The clinicians scored the methods according to ease of use and order of preference, and were also invited to make written comments. There was no significant difference in the incidence or magnitude of errors with the calculator method or either of the apps. Both apps were significantly faster to use than the calculator with Parkland method (mean response time 86.7 seconds for the calculator method; Mersey Burns 69.0 seconds, $p=0.017$; uBurn 71.7 seconds, $p=0.013$), but were not significantly different to each other. All methods showed a learning effect ($p<0.001$). There were no significant differences in ease of use or preference ranking for the different methods.

The data tables for Barnes et al. (2015) and Morris et al. (2014) are presented in the appendix.

A review of smartphone applications used to aid burns management (Wurzer et al. 2015) reported mainly on the functions and costs of 32 individual apps, 13 of which, including Mersey Burns, were calculator apps for estimating TBSA or total fluid requirement (TFR). All the apps were tested using simulated data for 1 male patient with 18% TBSA. The TFR for the first 24 hours was manually calculated using the Parkland formula as 5400 ml. The Mersey Burns app correlated with the calculated TFR.

Recent and ongoing studies

No ongoing or in-development trials on the Mersey Burns app for burn area assessment or fluid calculation in burns management were identified.

Costs and resource consequences

The Mersey Burns app is free to download, and has no direct cost implications – particularly the HTML5 compatible version, which could be used on computers available in clinical settings. There is a theoretical cost related to providing mobile devices if this were considered necessary, but it is likely that many clinicians already own smartphones or tablets. Using the app would not require any changes to current service provision.

Morris et al. (2014) found that Mersey Burns resulted in faster calculation of fluid requirements than the traditional paper method. However, they indicated that this is unlikely to be clinically significant in practice and therefore would not affect resource use.

No published evidence on the resource consequences of using Mersey Burns was identified.

Strengths and limitations of the evidence

The evidence for the clinical effectiveness of the Mersey Burns app is very limited in quantity and quality with only 2 papers identified. Both were clinical simulation studies and did not involve patients. In Barnes et al. (2015) participants were either shown a photograph of a child with a burn injury or instructed to assess a realistic prosthetic burn simulation. Participants in Morris et al. (2014) were given randomly generated simulated data to assess.

Both Barnes et al. (2015) and Morris et al. (2014) compared the Mersey Burns app with the current standard paper-based method (the Lund and Browder chart) to estimate TBSA. However, although Morris et al. used the Parkland formula, Barnes et al. (2015) did not explicitly state the method of fluid calculation used in the comparison. In all studies, the order in which the calculation methods were used was randomised to reduce bias. Morris et al. (2014) also blinded participants and investigators to the response times and correct answers in the scenarios. Barnes et al. (2015) state that 2 of the authors manually checked the fluid requirements calculated by the medical students and confirmed as either correct or incorrect. This may have resulted in analytical bias. No information is given about how the fluid requirements calculated in the clinician study were assessed. In the Morris et al. (2014) study, error magnitude was calculated using bespoke software. The studies involved participants with different levels of burns experience. The clinicians testing the app in the Morris et al. (2014) study were staff from a regional burns unit; all had previous experience of performing calculations using the Parkland formula. In the Barnes et al. (2015) study, the app was tested mainly by undergraduate medical students with no previous experience of burns management and only 20% (4/20) of the experienced clinician group (plastic surgeons) used the app. The participants in each of the studies may not reflect actual users.

In Barnes et al. (2015) students completed an anonymous questionnaire assessing usability measures of each fluid calculation method using a Likert scale. A Likert scale is an ordinal scale, typically with 5 points, which allows agreement or disagreement to be measured. No details were provided in Barnes et al. (2015) as to whether the statements in the Likert scale were validated. Likert scales may also produce unreliable results because: the 'middle' statement could be considered an easy option for the respondent when unsure; respondents avoid selecting the extreme options; or respondents select options that might be considered the 'desirable' response. The significance levels for each category were not presented clearly: it was not clear if all were statistically significant or only ease of use overall and ease of shading.

Three of the authors of the Barnes et al. (2015) study were involved in designing the Mersey Burns app.

Relevance to NICE guidance programmes

The use of the Mersey Burns app is not currently planned into any NICE guidance programme.

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Data tables

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Table 2: Summary of results of the Barnes et al. (2015) study

Table 3: Overview of the Morris et al. (2014) study

Table 4: Summary of results of the Morris et al. (2014) study

Table 1 Overview of the Barnes et al. (2015) study

Study component	Description
Objectives/hypotheses	To assess the speed and accuracy of calculations using the Mersey Burns app in comparison with a Lund and Browder paper chart when a burn is assessed by medical students and clinicians.
Study design	Validation study.
Setting	Simulated clinical environment.
Intervention and comparator	Intervention: Mersey Burns app (version not stated) Comparator: Lund and Browder paper chart and manual fluid calculation (Parkland formula used in the student study but method not stated for the clinician study).
Inclusion/exclusion criteria	Not applicable.
Primary outcomes	Speed and accuracy of total body surface area (TBSA) and fluid calculations, and user satisfaction.

Study component	Description
Methods	Two studies were conducted; the clinician study (first study) was used to inform the design of the student study (second study). Clinician study: Clinicians were shown a photograph of a child with a burn injury and were asked to calculate TBSA and devise a fluid resuscitation and maintenance fluid protocol. A standard paper chart to estimate TBSA was provided. Four of the plastic surgery staff assessed the same burn with the Mersey Burns app. Statistical tests: t tests and analysis of variance. Student study: Students were given a 1-hour lecture on burns management and fluid resuscitation involving demonstrations of the Lund and Browder chart and the Mersey Burns app. Students were then presented with a prosthetic burn simulation of a mixed burn injury and asked to calculate the TBSA and a fluid resuscitation protocol using both the Lund and Browder chart with a calculator and Mersey Burns app. Fluid calculations based on the TBSA calculated by each student were manually checked by 2 authors. Preference and ease of use were also assessed. The order of the app and chart were randomised. Statistical tests: Chi square and Student t tests.
Participants	Clinician pilot study with 10 plastic surgery consultants & specialist trainees and 10 emergency doctors. Student study with 42 senior undergraduate medical students (University of Liverpool) with no previous experience of burns management.

Study component	Description
Results	Clinician study: no significant difference in the calculations between the app and the paper chart for TBSA, fluid rate or fluid requirement. Significant difference in the variance between the app and the paper chart for total fluid ($p<0.05$) and background fluid ($p<0.0001$), with the paper chart showing greater variance. 40% of clinicians were uncertain how to calculate background fluid requirements in children and did not attempt to do so. These were not included in variance calculations. Student study: no significant difference for TBSA calculation between the app and the paper chart. Time to completion was significantly faster with the app. Accuracy of fluid calculation for the first 8 hours and the following 16 hours was correct in 100% cases using the app compared with the paper chart, with 62% of cases being accurate for 8-hour fluids and 64% for 16-hour fluids. Total fluid volume calculated was correct using the app in 100% of cases, and 81% of cases using the paper chart. Students favoured the app in the following categories: preference in emergency setting, confidence in output, accuracy, speed, ease of calculation, overall use ($p<0.0001$) and shading ($p=0.0007$).
Conclusions	The Mersey Burns app, when used by medical students with no previous experience of burns management, facilitated quicker and more accurate calculations than the Lund and Browder chart with manual fluid calculation. Students preferred the app.
Abbreviations: CI, confidence interval; TBSA, total burn surface area.	

Table 2 Summary of results from Barnes et al. (2015) study

	Mersey Burns app	Lund and Browder paper chart	Analysis
Primary outcome: TBSA percentage calculation (%, mean±SD)	Clinician study: 15.4±1.58 (range 13.2 to 17.0). Student study: 17.53±5.56 (range 12.4 to 38.5).	Clinician study: 17.4±3.56 (range 13.5 to 26.8). Student study: 17.52±5.45 (range 11.5 to 38.0).	Clinician study: no significant difference (p-value not reported). Student study: p=0.7 (no significant difference).
Selected secondary outcomes:			
Cases of correct total fluid calculations when compared with manual check by study authors	Student study: 100%	Student study: 81% (34/42). Clinician study: not reported.	Student study: 95% CI 0.17 (0.05 to 0.28). Clinician study showed a lower variance in fluid calculations using the app, $p<0.05$.
Accuracy of fluid rate calculation	Clinician study: not reported. Student study: 100% for first 8 hours and the following 16 hours.	Student study: for first 8 hours 62% (26/42), 0.33 (95% CI 0.17 to 0.49). Following 16 hours 64% (27/42), 0.33 (95% CI 0.18 to 0.48).	Clinician study: no significant difference in calculation or variance. Student study: first 8 hours p=0.0002, following 16 hours $p<0.0001$.

	Mersey Burns app	Lund and Browder paper chart	Analysis
Time to completion of calculations (minutes, mean±SD)	4.6±1.217 (range 3–7).	11.7±2.775 (range 6–17).	Mean difference 7.133 (95% CI 6.09 to 8.18).
Accuracy of calculations	Student study: Calculations were more likely to be accurate with the app.		Student study: p<0.001.
Preferences	Clinician study: not applicable. Student study: students favoured the app in the following categories: preference in emergency setting, confidence in output, accuracy, speed, ease of calculation, overall use (p<0.0001) and shading (p=0.0007).		
Abbreviations: CI, confidence interval; TBSA, total burn surface area.			

Table 3 Overview of the Morris et al. (2014) study

Study component	Description
Objectives/ hypotheses	To compare the accuracy and perceived usability of 2 smartphone apps and a general-purpose electronic calculator for calculating fluid requirements.
Study design	Validation study.
Setting	Clinical simulated environment. Participants were recruited from November 2012 to February 2013.
Intervention and comparator	Intervention: Mersey Burns app, version not stated (CE marked by MHRA). Intervention: uBurn app, version not stated (not licensed for clinical use when the study was conducted). Comparator: General-purpose electronic calculator for calculating fluid requirements using the Parkland formula.
Inclusion/ exclusion criteria	Not applicable.

Study component	Description
Primary outcomes	Speed and accuracy of fluid requirement calculations, ease of use for each method and preference.
Methods	Bespoke software randomly generated simulated clinical data, randomly allocated the sequence of calculation methods, recorded participants' responses and response times and calculated error magnitude. Participants calculated fluid requirements for 9 scenarios (3 for each: calculator, uBurn, Mersey Burns), rated ease of use (VAS) and preference (ranking), and made written comments. Data were analysed using ANOVA, Tukey's HSD test, Chi-squared test to consider impact of age and qualitative methods for free text responses.
Participants	34 participants of various clinical grades from a regional burns centre: consultant surgeons (5), consultant anaesthetists (2), SpR plastic surgery (8), SHO plastic surgery (12), SHO anaesthetics (1), nurse (6). All participants had previous experience of performing calculations using the Parkland formula; 82.4% (n=28) routinely used a calculator for determining fluid requirements.
Results	There was no significant difference in the incidence or magnitude of errors. Both apps were significantly faster than the calculator but not significantly different to each other. All methods showed a learning effect ($p<0.001$). The calculator was the easiest to use with a mean score (SD) of 12.3 (2.1) followed by Mersey Burns with 11.8 (2.7) and then uBurn with 11.3 (2.7). These differences were not significant. Preference ranking followed the same pattern with mean rankings (SD) of 1.85 (0.17), 1.94 (0.74) and 2.18 (0.90) for the calculator, Mersey Burns and uBurn respectively (not significant at $p=0.05$).
Conclusions	Both uBurn and the Mersey Burns apps were faster than the general-purpose calculator, though this is unlikely to be of clinical significance in practice. All 3 methods demonstrated similar rates and magnitude of error, and similar evidence of a learning effect. Both apps were deemed to be appropriate methods to aid estimation of fluid requirements for adult burns.
Abbreviations: ANOVA, analysis of variance; HSD, honestly significant difference.	

Table 4 Summary of results from Morris et al. (2014) study

	Mersey Burns app	uBurn app	Calculator method	Analysis
Primary outcome: Response time (seconds, mean±SD)	69.0±35.6	71.7±42.9	86.7±50.7	p=0.006 (ANOVA) Tukey's HSD test found the calculator to be significantly slower than both uBurn (p=0.013) and Mersey Burns (p=0.017). The difference between the 2 apps was not significant.
Selected secondary outcomes:				
Propensity for error	9.8%	7.8%	16.7%	p=0.065 There was no evidence of age or gender affecting the results.
Learning effect	There was strong evidence of learning across all 3 methods with response time falling dramatically with repeated attempts (p<0.001).			
Preference: Score (mean±SD)	11.8±2.7	11.3±2.7	12.3±2.1	Measure using a VAS ranging from 'very difficult' to 'very easy'. Differences were not statistically significant.
Preference: Ranking (mean±SD)	1.94±0.74	2.18±0.90	1.85±0.17	Differences were not statistically significant.

<table>
<tr><th></th><th>Mersey Burns app</th><th>uBurn app</th><th>Calculator method</th><th>Analysis</th></tr>
<tr><td>Qualitative analysis</td><td colspan="4">Summary of the strengths and weakness of uBurn app
Strengths
• Allows patient weight to be entered in 1 kg increments.
• Pre-hospital fluid taken into account.
• The entire calculation was shown on 1 page, so there was no need to navigate back and forth.
• Emphasised rate of fluid administration rather than total volume.
• It is possible to enter data quicker with a numeric key pad rather than a slider/wheel.
Weaknesses
• Episode of data loss when a tab was accidentally pressed.
• Does not emphasise importance of excluding erythema in assessment.
• Does not allow for variations of original Parkland formula for example 3 ml/kg/%TBSA.
• Slider interface made data entry slow and "fiddly".
• Option for multiple units of measurement (kg, lbs, minutes or hours) increased complexity and possible error.
• Does not emphasise that app and formulae are only guidelines.
Summary of the strengths and weakness of Mersey Burns app
Strengths
• Interface was more intuitive and easier overall.
• Option to estimate TBSA by drawing on touch screen.
Weaknesses
• No option to account for pre-hospital fluids.</td></tr>
</table>

	Mersey Burns app	uBurn app	Calculator method	Analysis
	• Navigating between pages was needed during a calculation. • Weight increments of 5 kg could affect accuracy. • Appeared to erroneously display formula as 2 ml/kg instead of 2 ml/kg/TBSA %.			
Abbreviations: ANOVA, analysis of variance; HSD, honestly significant difference; TBSA, total body surface area; VAS, visual analogue scale.				

Search strategy and evidence selection

Search strategy

A search was conducted to identify evidence on the clinical and cost effectiveness of the Mersey Burns app.

The strategy was developed in MEDLINE (Ovid). The strategy was devised using a combination of subject indexing terms and free text search terms that described the indication and free text search terms that specifically related to the technology. No limits were applied to the search.

The strategy was adapted for the following databases: Medline in Process, Embase, Cochrane Library (CENTRAL, CDSR, DARE, HTA, NHS EED), EconLit, Pubmed ('epub ahead of press' search only of key terms), Scopus and Web of Science (Web of Science – Science Citation Index and Conference Proceedings Citation Index Science). The searches returned a total of 24 references after duplicate removal.

Information supplied by the company and also the company's website were checked for relevant studies.

ClinicalTrials.gov and the International Clinical Trials Registry Platform (ICTRP) were searched to identify ongoing or in-development trials.

Evidence selection

Retrieved results were independently sifted by 2 researchers. From the 24 records obtained from the searches, 4 records were identified that related to Mersey Burns: 2 full-text study reports; 1 conference abstract and a review of smartphone apps for burns. The conference abstract was excluded as the data was reported in 1 of the full-text study reports.

About this briefing

Medtech innovation briefings summarise the published evidence and information available for individual medical technologies. The briefings provide information to aid local decision-making by clinicians, managers and procurement professionals.

Medtech innovation briefings aim to present information and critically review the strengths and weaknesses of the relevant evidence, but contain no recommendations and are not formal NICE guidance.

Development of this briefing

This briefing was developed for NICE by Cedar. The interim process and methods statement sets out the process NICE uses to select topics, and how the briefings are developed, quality-assured and approved for publication.

Project team

Cedar

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Specialist commentators

The following specialist commentators provided comments on a draft of this briefing:

- Dr Andy Ashton, Consultant in Emergency Medicine, Clinical Director Emergency Department, Whiston Hospital, Merseyside.
- Mr Baljit Dheansa, Consultant Plastic Surgeon, Queen Victoria Hospital, Sussex.
- Dr John Matthews, Clinical Lead for Cheshire and Mersey Major Trauma Network, Consultant in Emergency Medicine, Whiston Hospital, Merseyside.
- Professor Timothy Rainer, Professor of Emergency Medicine, Cardiff and Vale University Health Board, and Honorary Consultant, Cardiff University, Wales.

Declarations of interest

- Dr Andy Ashton is a consultant colleague at the same hospital as Rowan Pritchard Jones, the developer of Mersey Burns. They have collaborated on some IT projects.
- Mr Baljit Dheansa is a member of the national burns clinical reference group, a member of the South East Burns Operational Delivery Network, Clinical Advisor to Blond McIndoe Research Foundation and private practice in plastic surgery.

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