The effect of ambient outside temperatures on scoop stretchers

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Abstract

Background: Scoop stretchers are commonly used in the prehospital care of trauma patients. Patients' clothing is often removed early in the care pathway. There may be unidentified risks if scoop stretchers are particularly cold. **Aims**: The primary aim of this research was to establish if there is a positive correlation between scoop temperatures and outside temperatures when this equipment is stored without access to vehicle heating. **Methods**: The authors recruited volunteers at ambulance locations across Scotland to measure scoop temperatures using infrared thermometers. These were compared to outside temperatures at that time. Data were subject to bivariate quantitative analysis to assess correlation strength. **Findings**: Results demonstrated that there was a moderate-to-strong correlation between scoop temperatures and outside temperatures (mean +3.0°C; $P<0.001$). There was no significant difference for other variables measured. **Conclusion**: Without active heating, scoop stretchers will be only marginally warmer than the outside temperature, sometimes colder than the outside temperature and sometimes below freezing point.

Key words

● Ambulance ● Trauma ● Hypothermia ● Scoop ● Immobilisation ● Temperature

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In the UK, trauma is the leading cause of death in patients aged under 45 years (Brown et al, 2019). In 2018 in Scotland, around 21% of patients classified as major trauma (Injury Severity Score (ISS) >15) died from their injuries (Public Health Scotland, 2022).

In major trauma, the relationship between hypothermia and coagulopathy and mortality has been well described (Valeri et al, 1995; Fries and Martini, 2010; Balvers et al, 2016; Klauke et al, 2016).

Hypothermia is a predictor for mortality; hypothermia with acidosis and coagulopathy is often termed the 'triad of death' (Rotondo and Zonies, 1997). Graphical representation of the triad is often as an equilateral triangle. This may lead one to assume that all elements of the triad are equal in causality. However, in 2005, two large cohort retrospective studies both found that hypothermia was an independent predictor of mortality (Shafi et al, 2005; Wang et al, 2005). More recent research has identified it poses the same independent risk factor in patients with trauma (Balmer et al, 2022).

Hypothermia is often described as a core body temperature <35°C) (Eddy et al, 2000; Mitra et al, 2012; Søreide, 2014; Balmer et al, 2022). However, in cases of major trauma, it is suggested that hypothermia should be defined as a core body temperature <36°C (Helm et al, 1995; Tsuei and Kearney, 2004; Klauke et al, 2016).

In 2013, the Faculty of Prehospital Care Consensus Group at the Royal College of Surgeons of Edinburgh recommended that patients be placed 'skin to scoop' during the prehospital phase of trauma care (Moss et al, 2013). They introduced the concept of 'minimal handling' and 'one single movement'. Their focus was mainly on the risk of disruption of early blood clot formation (in pelvic injuries in particular). They acknowledged that hypothermia posed a significant risk to trauma patients. The risk of accidental or iatrogenic hypothermia with the triad and poorer patient outcomes is well established (Gentilello et al, 1997; Balmer et al, 2002; Tsuei and Kearney, 2004; Shafi et al, 2005; Wang et al, 2005; Ireland et al, 2011; Mitra et al, 2012).

In 2012, the HypoTraum study demonstrated a similar association between hypothermia and poorer patient outcomes and found an association between the removal of clothing in the prehospital phase, ambulance temperature and environmental factors with hypothermia on arrival at emergency departments (Lapostolle et al, 2012).

In 2018, a Scandinavian study found that almost all trauma patients were hypothermic before the arrival of emergency medical services (EMS) and the vast majority of them (91%) experienced further reductions in core body temperature while care took place at the scene of the incident (Eidstuen et al, 2018). Similar to the HypoTraum study, the authors found that removal of clothing (among other factors) exacerbated heat loss.

There is now a strong consensus in the literature that avoidance of hypothermia in the prehospital phase of patient care is vital in reducing the risk of poorer outcomes (Ireland et al, 2011; Lapostolle et al, 2012; Eidstuen et al, 2018; Rösli et al, 2020; van Veelen et al, 2021; Balmer et al, 2022).

Between 2013 and 2019, the number of trauma patients received at Scottish hospitals increased by 89.5% (Scottish Trauma Audit Group (STAG), 2020). Increases in trauma incidence have been identified in other developed countries (Kehoe et al, 2015; DiMaggio et al, 2016; Pointer, 2019).

In Scotland in 2014–2015, there were 1313 cases of major trauma (ISS>15), with around 9.25% of all trauma patients suffering a pelvic injury (STAG, 2016). Pelvic fractures are potentially life-threatening because they can involve internal vascular damage and catastrophic haemorrhage into the retroperitoneal space (STAG, 2016). Any significant or high-energy impact can have catastrophic haemorrhagic effects. The pelvis provides support, containment and protection of pelvic cavity structures, including major blood vessels (DeSilva and Rosenberg, 2017).

Falls from height and road traffic collisions (particularly involving motorcycles) are most commonly associated with serious pelvic trauma (STAG, 2020).

There is strong consensus within the literature that early recognition, having a low index of suspicion for pelvic injury, the application of pelvic binders, minimal movement and rapid transportation to an appropriate trauma facility are crucial in reducing mortality rates in patients with pelvic trauma (Lee and Porter, 2007; Moss et al, 2013; DeSilva and Rosenberg, 2017; Ward et al, 2018; Brown et al, 2019).

In humans, the hypothalamus regulates core body temperature by attempting to maintain a continuous balance between heat loss and heat gain (Vella and Kravitz, 2004). Heat can be lost from the body in four main ways: conduction; convection; evaporation; and radiation (Koop and Tadi, 2022). In addition, some researchers state respiration is a fifth source of heat loss in humans (Havenith, 2002).

Figure 1. Scoop stretchers are stored in a cupboard with only a small vent to the saloon of the ambulance

Heat is lost through conduction by physical contact with another object (Tsuei and Kearney, 2004; Vella and Kravitz, 2004). People who are in contact with cold surfaces for prolonged periods and who are in a supine position may be at greater risk of conductive heat loss (Havenith, 2018).

Although not specifically mentioned in the Joint Royal Colleges Ambulance Liaison Committee (JRCALC) UK ambulance guidelines (Brown et al, 2019), there is an awareness of the Faculty of Prehospital Care consensus statement (Moss et al, 2013) on minimal patient handling, and UK ambulance crews often place injured patients 'skin to scoop'.

The scoop stretcher used by land and air ambulances in the Scottish Ambulance Service is the Ferno 65 EXL (Ferno-Washington). However, one air ambulance uses the Hartwell CombiCarrierII (Hartwell Medical). From 2015, a large-scale redesign of land vehicles saw the scoop stretcher moved from being stored in the saloon of accident and emergency ambulances (which is heated by the vehicle heater) into a side-accessed cupboard, with a small, slotted internal vent (*Figure 1*) providing passive access to the heat produced to warm the saloon.

No data are available on the temperature characteristics of scoop stretchers or their association with outside temperatures. This is not surprising as the general lack of evidence on the prehospital management of hypothermia is notable, a finding highlighted by Haverkamp et al (2018), who also recognised that most research in this area was carried out some time ago.

Given the risks that hypothermia poses to major trauma patients, it is important to understand the temperature characteristics of scoop stretchers as the posterior skin surface of trauma patients can be in contact with this piece of equipment for lengthy periods of time.

Aims

The primary aim of this study was to establish whether there is a positive correlation between scoop and outside temperatures when this equipment is stored without vehicle heating.

The secondary aims were to establish whether any correlation was affected by the time of year or parking arrangements (whether parked inside or outside), and if there were differences in correlation if ambulances were being used or if a scoop stretcher had a patient placed on it recently.

Methods

The study used bivariate quantitative analysis to assess the correlation strength between scoop and outside temperatures. Data were collected between 1 July 2021 and 26 January 2022 (30 weeks).

Figure 2. For consistency, stickers at the same place on scoop stretchers provided a target for thermometers

To assess seasonal differences or influences, the authors grouped data within three classifications of: summer period (1 July 2021–8 September 2021); autumn period (9 September 2021–17 November 2021); and winter period (18 November 2021–26 January 2022). Parking arrangements and whether a patient had been placed on the scoop within the past hour was also recorded.

Volunteers were recruited at ambulance locations across Scotland to record and send temperature data. Staff at these locations were asked to measure the surface temperature of scoop stretchers in ambulance vehicles using infrared (IR) hand-held thermometers. These are non-contact devices and are a fast, convenient way to take measurements of surface temperatures. The accuracy and reliability of non-contact IR thermometers are well established, with an accuracy tolerance given as ±2°C, but they usually provide a measurement accuracy to within 1°C (Vavilov, 2014). Volunteers were given instructions on how to use the thermometers. To aid consistency, ambulance vehicles involved in the study had small polyurethane stickers placed at the same location on each of their scoop stretchers as an 'aiming point' for the IR thermometer (*Figure 2*). This was to ensure ambulance crews were measuring the temperature on the same point on all scoop stretchers.

Each time volunteers collected a scoop temperature reading, a smartphone weather application recorded the outside temperature at that location, at that time. The weather app selected was the UK Met Office app. This was chosen because of its familiarity in the UK, because of the large number of weather stations used and because it offers real time temperature monitoring using highly accurate and stable platinum resistance thermometers, providing highly reliable temperature data (Strangeways, 2019; Met Office, 2023). Data were recorded manually and a lead person at each location sent the data on a periodic basis via Microsoft Forms.

Twenty ambulance locations provided data for the study. Fifty-eight land ambulances and two air ambulances were included. In total, 1390 temperatures were recorded. Forty-five outliers were removed (3.24% of all data points). For the purposes of the study, an outlier was defined as a difference of ±10°C between scoop stretcher and outside temperatures. Twelve obvious errors were manually corrected (e.g. temperatures recorded in Fahrenheit instead of Celsius).

The remaining 1345 scoop stretcher temperatures and their associated outside temperatures were included in the data analysis. Of these, 1288 were land ambulance readings and 57 were taken in an aircraft. Mean, median,

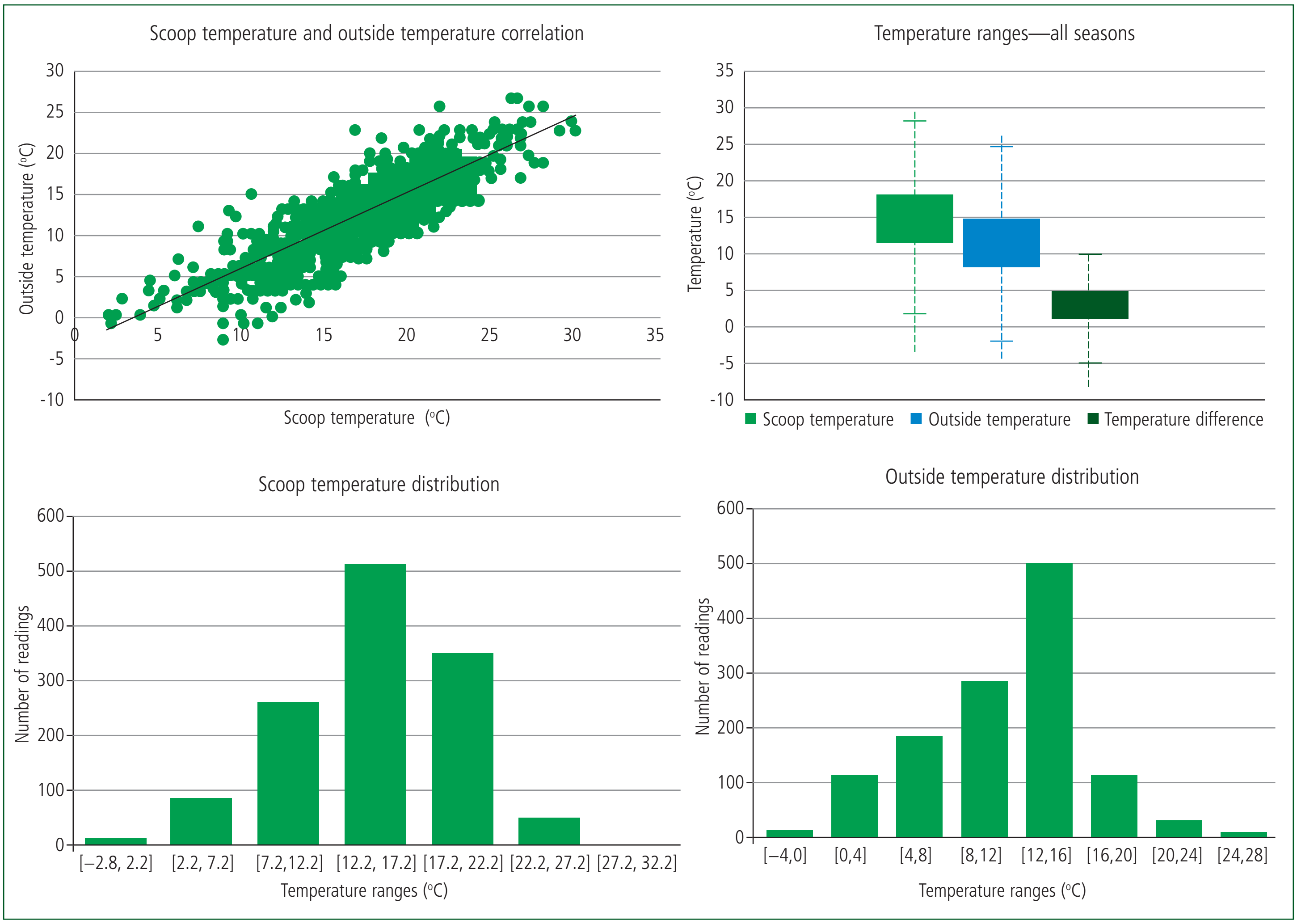

Figure 3. All land vehicles: scoop and external temperatures

standard deviation and interquartile range were calculated. Bivariate analysis was carried out to assess correlation strength. This was done using Pearson's correlation analysis, after assessing the normality assumption of the data. Descriptive summary statistics were also provided.

Ethical approval was not required. The Scottish Ambulance Service Research and Development Group approved the study.

Results

All scoop temperature data were normally distributed. The highest recorded scoop temperature was 36.5°C and the lowest was −2.8°C (below freezing). The largest positive difference in temperature was +17.5°C and the largest negative difference was −7.8°C.

For land ambulances, across all seasons, there was a strong positive correlation (r(1286)=0.83) between scoop temperatures and outside temperatures, with a mean scoop temperature of 14.7°C and a mean positive temperature difference of +3.0°C (*P*<0.001). (*Figure 3*)

During the summer period, there was a moderate positive correlation (r(634)=0.64), with a mean scoop temperature of 17.7°C and a mean positive temperature difference of +3.0°C (*P*<0.001). Over the autumn period, there was a strong positive correlation (r(354)=0.74), with a mean scoop temperature of 13.7°C and a mean positive temperature difference of +2.6°C (*P*<0.001). For the winter period, there was a moderate positive correlation (r(294)=0.64) with a mean scoop temperature of 9.3°C and a mean positive temperature difference of +3.7°C (*P*<0.001).

Where land ambulances were parked outside, across all seasons, there was a strong positive correlation with the outside temperature (r(1120)=0.84), with a mean scoop temperature of 14.0°C and a mean positive temperature difference of +2.7°C (*P*<0.001). When land ambulances were parked inside, across all seasons, a strong positive correlation was found with the outside temperature (r(164)=0.71), with a mean scoop temperature of 19.3°C and a mean positive temperature difference of +5.3°C (*P*<0.001).

Key points

- Clothing is often removed early in the care pathway of trauma patients, and there may be unidentified risks if scoop stretchers are particularly cold
- There is evidence supporting both the removal of patients' clothing in the prehospital phase of care as well as evidence supporting keeping patients clothed
- The thermodynamics of scoop stretchers have not been comprehensively assessed in the ambulance service environment
- Without access to active heating, the surface temperature of scoop stretchers are generally only marginally warmer than the outside temperature and occasionally colder
- There is a moderate-to-strong correlation between the temperature of scoop stretchers and the outside temperature at the time

Where land ambulances had been in use in the past hour, across all seasons, a strong positive correlation was demonstrated with the outside temperature (r(413)=0.86), with a mean scoop temperature of 15.1°C and a mean positive temperature difference of +3.6°C (*P*<.001). Regarding land ambulances that had not been used in the past hour, across all seasons, there a strong positive correlation with the outside temperature (r(871)=0.83), with a mean scoop temperature of 14.5°C and a mean positive temperature difference of +2.8°C (*P*<0.001).

When patients had been placed on scoop stretchers within the past hour, across all seasons, a strong positive correlation was demonstrated with the outside temperature (r(11)=0.86), with a mean scoop temperature of 19.4°C and a mean positive temperature difference of +6.1°C (*P*<0.001).

For air ambulances, across all seasons, there was a moderate positive correlation with the outside temperature (r(55)=0.60) with a mean scoop temperature of 17.7°C and a mean positive temperature difference of +2.9°C (*P*<0.002). For summer, there was a moderate positive correlation with the outside temperature (r(51)=0.57). There were not enough data for autumn and winter to carry out reliable analysis.

Tables 1 and *2* show the results for all land and all air ambulance vehicles.

Table 1. All land ambulances

Summer period (1 July–8 September 2021)				**r**	**0.64**	**r interpr =**	**Moderate**
	Records	Mean	Median	Max	Min	SD	IQR
Scoop	636	17.7	17.9	29.3	8.8	3.3	4.7
Outside	636	14.8	14.0	26.0	7.0	3.0	3.0
Difference	636	3.0	2.7	9.7	-7.8	2.7	3.8
Autumn period (9 September–17 November 2021)				**r**	**0.74**	**r interpr =**	**Strong**
	Records	Mean	Median	Max	Min	StDev	IQR
Scoop	356	13.7	14.0	24.0	1.9	3.9	5.8
Outside	356	11.0	11.0	19.0	2.0	3.5	5.0
Difference	356	2.6	2.4	9.5	-6.6	2.7	3.7
Winter period (18 November 2021–26 January 2022)				**r**	**0.64**	**r interpr =**	**Moderate**
	Records	Mean	Median	Max	Min	StDev	IQR
Scoop	296	9.4	9.8	19.2	-2.8	3.9	4.6
Outside	296	5.6	6.0	14.0	-4.0	3.5	5.0
Difference	296	3.7	3.5	9.9	-7.0	3.2	4.9
Whole study period (1 July 2021–26 January 2022)				**r**	**0.83**	**r interpr * =**	**Strong**
	Records	Mean	Median	Max	Min	SD	IQR
Scoop	1288	14.7	15.0	29.3	-2.8	5.0	6.8
Outside	1288	11.6	13.0	26.0	-4.0	4.9	7.0
Difference	1288	3.0	2.9	9.9	-7.8	2.9	4.0

* r interpr: the following criteria were used to interpret correlation (r): 0.00–10.0: no correlation
0.11–0.39: weak correlation
0.40–0.69: moderate correlation
0.70–0.89: strong correlation
0.90–1.00: very strong correlation

r: Pearson's correlation coefficient; max: maximum value; min: minimum value; IQR: interquartile range; SD: standard deviation

Table 2. All air ambulances

Summer period (1 July-8 September 2021)				**r**	**0.57**	**r interpr ***	**Moderate**
	Records	Mean	Median	Max	Min	StDev	IQR
Scoop	53	18.0	17.2	28.5	14.3	2.8	2.9
Outside	53	14.9	15.0	23.0	9.0	2.8	4.0
Difference	53	3.0	3.1	9.8	-3.2	2.6	3.9
Autumn period (9 September–17 November 2021)				**r**	**0.65**	**r interpr ***	**Moderate**
	Records	Mean	Median	Max	Min	StDev	IQR
Scoop	4	13.6	13.5	16.3	11.0	2.2	1.6
Outside	4	12.5	12.5	15.0	10.0	2.1	2
Difference	4	1.1	1.0	3.3	-1.0	1.8	1.5
Winter period (18 November 2021–26 January 2022)				**r**		**r interpr * =**	**N/A**
	Records	Mean	Median	Max	Min	StDev	IQR
Scoop	0						
Outside	0	No data					
Difference	0						
Whole study period (1 July 2021–26 January 2022)				**r**	**0.60**	**r interpr * =**	**Moderate**
	Records	Mean	Median	Max	Min	StDev	IQR
Scoop	57	17.7	17.0	28.5	11.0	3.0	3.0
Outside	57	14.8	15.0	23.0	9.0	2.8	3.0
Difference	57	2.9	3.0	9.8	-3.2	2.6	3.8

* r interpr: the following criteria were used to interpret correlation (r): 0.00–10.0: no correlation
0.11–0.39: weak correlation
0.40–0.69: moderate correlation
0.70–0.89: strong correlation
0.90–1.00: very strong correlation

r: Pearson's correlation coefficient; max: maximum value; min: minimum value; IQR: interquartile range; SD: standard deviation

Discussion

There was a moderate to strong positive correlation between scoop stretcher temperatures and outside temperatures. Correlation was stronger in the autumn period and when vehicles were parked outside. Vehicles that were parked inside a garage had warmer mean scoop temperatures than those parked outside (19.1°C versus 14.0°C) and had a higher mean difference in temperature (5.3°C versus 2.7°C). None of the vehicles that were parked inside had scoop temperatures below 14.3°C.

There were small differences in mean scoop temperatures and mean temperature differences when comparing seasons or whether vehicles had been in use in the past hour but none were significant.

Scoop stretchers on which a patient had been placed within the past hour had twice the mean temperature difference than the mean for all records (+6.1°C versus +3.0°C), which suggests some heat transference had taken place. The study did not attempt to assess how that heat transference had taken place (e.g. through patient contact, emergency medical worker contact or a warm ambulance environment).

A number of scoop stretchers were below 0°C (n=6). All were at locations with outside parking, and all had scoop temperatures measured between

CPD Reflection Questions

- How could this research specifically inform my own management of trauma patients?
- How might I protect patients against scoop stretchers which are very cold?
- What could ambulance services do to mitigate against scoop stretchers becoming too cold?

7am and 9am. Two had been in use in the past hour and four had not been used in the past hour (parked outside during the night).

Limitations

The authors designed the study to minimise bias as much as possible and to provide as much consistency and internal validity as possible.

Locations were selected by means of volunteering. This introduced an element of randomisation. While the study collected a large amount of quantitative data, the authors acknowledge the limitations of this research. Only 20 ambulance locations were used from a possible 160 in Scotland. Having more locations could have meant more data were provided and therefore would perhaps have given more reliable results.

Some locations sent in data regularly while others sent only small amounts over the study period. This inevitably results in some locations having a greater influence over the results. While this is a source of possible bias, the authors feel that this has not negatively impacted the results because of the large amount of data collected from other locations.

One type of organisation was involved. Including other providers (volunteer organisations, mountain rescue services, military or coastguard) would have provided additional data and a design providing some external validity.

Conclusion

Without access to active heating, the surface temperature of scoop stretchers is moderately or strongly positively correlated with the outside temperature at that time (generally only marginally warmer than the outside temperature).

While there are small differences in correlation between seasons and when vehicles are in use versus not being used, none of these differences are significant.

Parking inside seems to protect scoop stretchers from becoming very cold, demonstrating a lower positive correlation to outside temperatures. The risk of scoop temperatures being below 0°C is highest when vehicles are parked outside overnight, in the winter season and when outside temperatures have been below freezing.

Ambulance services with vehicles that store scoop stretchers without access to vehicle heating now have data to assess the likely temperature of their scoop stretchers.

The authors consider the results to be generalisable to ambulance services that store scoop stretchers this way. Although the data involve low numbers, it seems likely that heat is transferred from patient to scoop and, given the risks of hypothermia to patients with trauma, more research is needed to accurately understand the thermodynamics of scoop stretchers and the possible implications for patients. JPP

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