Reducing short-acting beta-agonist overprescribing in asthma: lessons from a quality-improvement prescribing project in East London

INTRODUCTION

Frequent use of short-acting beta-agonists (SABAs) is a recognised marker of poor control1 and a potentially modifiable warning sign of impending serious asthma attacks2–4 and asthma death.7,11 Asthma control is defined as the extent to which the manifestations of asthma, commonly wheeze, shortness of breath, chest tightness, cough, and variable expiratory airflow limitation, can be observed in a patient on their current treatment.12–14 Control can be assessed by current symptoms and is indicative of future adverse outcomes.1,12 In East London, admission to hospital for acute asthma is 14% above the average for London, with hospital admissions rising from 1.3 to 7.5 per 100 asthma population as the number of SABA inhalers prescribed rises from 1–3 to >12 a year.15

In addition to the individual patient harm associated with excess prescription of SABAs, pressurised metered-dose inhalers are a major contributor to healthcare-associated carbon footprint, and thereby global warming.16 Hence, reducing SABA overprescribing is important both for individuals and for global health. The dangers of SABA overprescribing have been highlighted in national (British Thoracic Society [BTS])5 and National Review of Asthma Deaths) and international12 guidance for many years. However, SABA overprescribing remains common across healthcare systems as highlighted in the recent SABINA studies.4 Notably, SABA overprescribing is more common in the UK than other European countries. Recent data show that SABA overprescribing (defined as collection of ≥2 SABA canisters/year) is associated with a dose-dependent increased risk of all-cause mortality and increased use of antidepressants, hypnotics, and sedatives, suggesting that those overprescribed SABA are a frailer patient group.17 Another recent study found that SABA overprescribing (≥3 prescribed inhalers/year) was prevalent across all GINA steps, which may indicate suboptimal asthma control,18 and concludes that further studies need to investigate the reasons behind SABA overprescribing, as well as effective interventions to reduce it.

Electronic alerts can reduce excessive prescribing of SABAs when delivered as part of a multicomponent intervention.19 In 2015, Asthma UK in conjunction with EMIS Web released a prescribing alert to highlight patients prescribed excessive SABAs. This activates if there are three prescriptions for SABA overprescribing, with repeat dispensing strongly linked to SABA overprescribing (odds ratio 6.52; 95% confidence interval = 4.64 to 9.41). Increasing severity of asthma and multimorbidity were also independent predictors of SABA overprescribing.

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Submitted: 29 December 2021. Editor’s response: 8 February 2022; final acceptance: 25 March 2022. ©The Authors
This is the full-length article (published online 23 Aug 2022) of an abridged version published in print. Cite this version as: Br J Gen Pract 2022; DOI: https://doi.org/10.3399/BJGP.2021.0725
to reduce SABA overprescribing in East London. In this first step the aim is to:

• describe baseline data on SABA overprescribing in East London;
• standardise the calculation of prescription rates for SABA and inhaled corticosteroid (ICS) inhalers across formulations, taking into account the number of items on prescriptions;
• examine prescription modality as a previously underappreciated factor in SABA overprescribing.

METHOD
Design and setting
This was a cross-sectional study using primary care electronic health data from 734,382 patients registered at all 117 practices in the East London boroughs of Newham, Tower Hamlets and Waltham Forest. In the 2011 UK census, 55% of the population in these boroughs were recorded as being of minority multi-ethnicities, and the English indices of deprivation 2015 show that these localities fall into the top decile of the most socially deprived boroughs in England. The study population included patients aged 5–80 years registered at the practice for ≥1 year before data extraction in February 2020. All participants had a coded diagnosis of asthma and ≥1 prescription for inhaled asthma medication in the previous year.

Data collection
Data were extracted on secure N3 terminals from EMIS Web. All data were anonymous and managed according to UK NHS information governance requirements. Demographic variables included age, sex, and self-reported ethnicity captured at registration with the practice or during routine consultations. Ethnic categories were based on the 18 categories of the UK 2011 census and were combined into four groups reflecting the study population.

Clinical measures included the latest value for smoking status, body mass index, and BTS asthma management step. To assess the burden of long-term conditions in the study population diagnostic data were extracted on 16 conditions that form part of the UK Quality and Outcomes Framework (QOF), using the earliest recorded diagnostic code before the start of the study, based on version 44 of the QOF business rule set. SNOMED codes (www.snomed.org) for chronic rhinitis and generalised anxiety were added to this. Prescribing data included all inhaled asthma medications and discrete courses of oral steroids in the previous year. All SABA inhalers were standardised to salbutamol 100 µg/dose (200-dose inhaler), and all inhaled steroid preparations were standardised using a method presented in Supplementary Information S1 and Supplementary Table S1.

Prescribing modalities included acute (provided by clinicians in response to an acute episode of illness) and automatic (automatic prescriptions are used for patients who will require medication without fail each month, for example, nursing home residents), repeat prescribing (regular long-term medications), and repeat dispensing (issued by a pharmacist from pre-authorised prescriptions for up to a year).

Statistical analysis
The primary outcome measure was the proportion of asthma patients prescribed ≥6 standard SABA 100 µg/dose (200-dose salbutamol inhaler) equivalent inhalers in the previous 12 months. All statistical analysis was undertaken in R (version 4.0.2). Both univariate and multivariate models were fitted. Sensitivity analyses were conducted to explore different groupings of comorbidities.

RESULTS
Among the GP-registered population of 734,382, there were 30,694 people with asthma who fitted the study criteria (see Supplementary Figure S1). The characteristics of the study population are shown in Table 1, with the univariate odds for SABA overprescribing ≥6 SABA a year.

Older adults had higher risks of SABA overprescribing, as did those with increasing numbers of physical and mental comorbidities. Prescription modality — in particular repeat dispensing — was also strongly associated with the risk of SABA overprescribing in East London. In this first step the aim is to:

• describe baseline data on SABA overprescribing in East London;
• standardise the calculation of prescription rates for SABA and inhaled corticosteroid (ICS) inhalers across formulations, taking into account the number of items on prescriptions;
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overprescribing. In keeping with more severe disease, there was a significant association between higher asthma management step and increased SABA prescriptions. Furthermore, consistent with airways inflammation as a risk factor for uncontrolled asthma, there was a significant association between eosinophilia (eosinophil count ≥0.3) and SABA overprescribing. Children were found to have the lowest risk of SABA overprescribing; hence

| Variable                     | Number Univariate analysisa | OR     | 95% CI      | P-value |
|------------------------------|----------------------------|--------|-------------|---------|
|                              | SABA <6 SABA ≥6 OR 95% CI  |        |             |         |
| **Age, years**               |                           |        |             |         |
| Adult (18–60)                | 13,098 5,970               | Ref    |             |         |
| Child (6–17)                 | 4628 1972                  | 0.90   | 0.84 to 0.95 | <0.01  |
| Older adult (>60)            | 2,686 2,129                | 1.75   | 1.44 to 1.86 | <0.01  |
| **Sex**                      |                           |        |             |         |
| Male                         | 9,276 4,651                | Ref    |             |         |
| Female                       | 11,336 5,430               | 0.96   | 0.91 to 1.00 | 0.06   |
| **Ethnicity**                |                           |        |             |         |
| White                        | 7,048 3,664                | Ref    |             |         |
| Mixed                        | 1,052 474                  | 0.87   | 0.77 to 0.97 | 0.02   |
| Asian or Asian British       | 8,572 4,388                | 0.98   | 0.93 to 1.04 | 0.58   |
| Black                        | 2,011 822                  | 0.79   | 0.72 to 0.86 | <0.01  |
| Other                        | 243 107                    | 0.86   | 0.68 to 1.08 | 0.21   |
| Not stated/unclassified      | 1,686 624                  | 0.71   | 0.64 to 0.79 | <0.01  |
| **IMD score**                |                           |        |             |         |
| 1 (least deprived)           | 2,622 1,306                | Ref    |             |         |
| 2                            | 3,756 1,751                | 1.01   | 0.92 to 1.10 | 0.87   |
| 3                            | 4,526 2,226                | 1.07   | 0.98 to 1.16 | 0.12   |
| 4                            | 5,199 2,506                | 1.04   | 0.96 to 1.13 | 0.33   |
| 5 (most deprived)            | 4,309 2,283                | 1.14   | 1.05 to 1.24 | <0.01  |
| **Prescription type**        |                           |        |             |         |
| Repeat                       | 11,416 7,895               | Ref    |             |         |
| Acute and automaticb         | 9,152 5,955                | 0.31   | 0.29 to 0.33 | <0.01  |
| Repeat dispensed             | 44 231                     | 7.59   | 5.55 to 10.63 | <0.01  |
| **Smoking**                  |                           |        |             |         |
| Never                        | 15,345 6,823               | Ref    |             |         |
| Current                      | 2,417 1,538                | 1.43   | 1.33 to 1.53 | <0.01  |
| Ex-smoker                    | 2,850 1,720                | 1.36   | 1.27 to 1.45 | <0.01  |
| **BTS Asthma step**          |                           |        |             |         |
| Step 1                       | 3,396 911                  | Ref    |             |         |
| Step 2                       | 8,415 2,492                | 1.90   | 1.75 to 2.06 | <0.01  |
| Step 3                       | 2,029 698                  | 3.47   | 3.34 to 4.04 | <0.01  |
| Step 4 + step5               | 155 352                    | 8.47   | 6.93 to 10.39 | <0.01  |
| Unknown                      | 6,617 2,528                | 1.42   | 1.31 to 1.55 | <0.01  |
| **Oral steroid courses**     |                           |        |             |         |
| Zero                         | 17,622 7,565               | Ref    |             |         |
| 1                            | 2,159 1,373                | 1.48   | 1.38 to 1.59 | <0.01  |
| 2                            | 4,63 480                   | 2.41   | 2.12 to 2.75 | <0.01  |
| ≥3                           | 368 663                    | 4.20   | 3.69 to 4.78 | <0.01  |
| **Physical comorbidities**   |                           |        |             |         |
| 0                            | 8,263 3,113                | Ref    |             |         |
| 1                            | 8,102 3,618                | 1.19   | 1.12 to 1.25 | <0.01  |
| 2–3                          | 3,618 2,677                | 1.96   | 1.84 to 2.10 | <0.01  |
| ≥4                           | 629 673                    | 2.84   | 2.53 to 3.19 | <0.01  |
| **Mental comorbidities**     |                           |        |             |         |
| 0                            | 15,314 6,703               | Ref    |             |         |
| 1                            | 2,926 1,667                | 1.30   | 1.22 to 1.39 | <0.01  |
| 2                            | 2,218 1,528                | 1.57   | 1.47 to 1.69 | <0.01  |
| 3                            | 154 183                    | 2.71   | 2.19 to 3.37 | <0.01  |

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subsequent analyses have been undertaken in the adult population only.

Analysis by GP practice (see Figure 1) shows a 10-fold variation between practices in the percentage of asthma patients prescribed ≥6 SABA in the previous 12 months (range <6% to 60%). This variability was distributed uniformly across practices of all sizes. About one-fifth of practices had an overprescribing rate of <20% (23/117).

To identify factors associated with SABA overprescribing among adults a multivariate model was used (Table 2). Severity of asthma, as measured by asthma step and by number of oral steroid prescriptions, were both major independent predictors of SABA overprescribing.

The multivariate analysis confirmed that older adults (odds ratio [OR] 1.34, 95% confidence interval [CI] = 1.24 to 1.45), smoking, and increasing number of both physical and mental comorbidities were independent predictors of SABA overprescribing.

This study has also confirmed that prescribing modality and in particular repeat dispensing (where repeat medications are managed by community pharmacists) was strongly associated with excess SABA use. Repeat dispensing compared with repeat prescribing had an OR of 6.52 (95% CI = 4.64 to 9.41). Although patients on

Table 1 Continued. Characteristics of the asthma study population

| Variable          | Number | SABA <6 | SABA ≥6 | OR     | 95% CI     | P-value |
|-------------------|--------|---------|---------|--------|------------|---------|
| MPR category*     |        |         |         |        |            |         |
| Reasonable use    | 2826   | 5109    | Ref     |        |            |         |
| Zero use          | 4360   | 657     | 0.08    | 0.07 to 0.09 | 0.08    |
| Underuse          | 13,314 | 2,109   | 0.08    | 0.08 to 0.09 | 0.08    |
| Overuse           | 112    | 2,206   | 10.80   | 8.73 to 13.53 | 10.80   |
| Eosinophil count  |        |         |         |        |            |         |
| No count          | 683    | 227     | –       |        |            |         |
| <0.3              | 890    | 4,375   | Ref     |        |            |         |
| ≥0.3              | 6394   | 3,507   | 1.2     | 1.06 to 1.18 | <0.01   |

*Univariate odds of using ≥6 SABA inhalers in the previous 12 months. *The number of patients on automatic prescription was 285 for SABA <6 and 228 for SABA ≥6, respectively. *MPR category: see details of MPR calculation in Supplementary Information S1. CI = confidence interval. IMD = Index of Multiple Deprivation. MPR = medication prescription refill. OR = odds ratio. Ref = reference. SABA = short-acting beta-agonist.
Previous studies have suggested that overprescribing of SABAs is associated with underprescribing of ICSs. Using the more precise measures of the medication prescription refill (MPR) % for preventer ICS/ICS-LABA (long-acting beta 2-agonists) inhalers, which compares prescribed ICS against standard expected use, in the

Table 2. Logistic regression model showing the predictors of SABA overprescribing (≥ 6 SABA in the previous 12 months) for adults with asthma

| Variables                        | Number | SABA ≤ 6 | SABA ≥ 6 | OR     | 95% CI | P-value |
|---------------------------------|--------|----------|----------|--------|--------|---------|
| Age                             |        |          |          |        |        |         |
| Adult                           | 13 098 | 5970     | 1.34     | 1.24 to 1.45 | <0.01 |
| Older adult (>60)                | 2686   | 2139     | 1.38     | 1.24 to 1.52 | <0.01 |
| Sex                             |        |          |          |        |        |         |
| Male                            | 6392   | 3430     | 0.85     | 0.90 to 0.80 | <0.01 |
| Female                          | 9393   | 4679     |          |        |        |         |
| Ethnicity                       |        |          |          |        |        |         |
| White                           | 6066   | 3297     | 0.91     | 0.79 to 1.05 | 0.01 |
| Mixed                           | 6082   | 3297     | 0.87     | 0.75 to 1.00 | 0.39 |
| Asian or Asian British          | 1568   | 655      | 1.13     | 1.05 to 1.21 | 0.02 |
| Black                           | 778    | 352      | 0.94     | 0.84 to 1.06 | 0.15 |
| Other                           | 186    | 81       | 1.01     | 0.76 to 1.36 | 0.03 |
| Not stated/Unclassified         | 1104   | 427      | 0.84     | 0.74 to 0.96 | 0.03 |
| Prescription type               |        |          |          |        |        |         |
| Repeat                          | 8671   | 6392     |          |        |        |         |
| Acute and automatic             | 7074   | 1513     | 0.29     | 0.27 to 0.31 | <0.01 |
| Repeat dispensed                | 39     | 204      | 6.52     | 4.64 to 9.41 | <0.01 |
| Smoking                         |        |          |          |        |        |         |
| Never                           | 10 512 | 4848     |          |        |        |         |
| Current                         | 2395   | 1524     | 1.51     | 1.38 to 1.63 | <0.01 |
| Ex-smoker                       | 2840   | 1716     | 1.21     | 1.13 to 1.32 | <0.01 |
| Asthma step                     |        |          |          |        |        |         |
| Step 1                          | 2485   | 670      |          |        |        |         |
| Step 2                          | 6218   | 3289     | 1.79     | 1.62 to 1.97 | <0.01 |
| Step 3                          | 1864   | 1826     | 2.87     | 2.56 to 3.21 | <0.01 |
| Step 4+5                        | 136    | 323      | 4.99     | 3.96 to 6.30 | <0.01 |
| Unknown                         | 5882   | 2001     | 1.19     | 1.05 to 1.35 | <0.01 |
| Oral steroid                    |        |          |          |        |        |         |
| Zero                            | 13 188 | 5955     |          |        |        |         |
| 1                               | 1851   | 1139     | 1.35     | 1.21 to 1.45 | <0.01 |
| 2                               | 392    | 412      | 2.67     | 2.48 to 2.71 | <0.01 |
| ≥3                              | 354    | 603      | 2.90     | 2.46 to 3.31 | <0.01 |
| Physical comorbidities           |        |          |          |        |        |         |
| 0                               | 5601   | 2044     |          |        |        |         |
| 1                               | 6307   | 2802     | 1.07     | 1.00 to 1.14 | 0.05 |
| 2–3                             | 3448   | 2591     | 1.58     | 1.47 to 1.73 | <0.01 |
| ≥4                              | 628    | 672      | 1.86     | 1.61 to 2.13 | <0.01 |
| Mental comorbidities             |        |          |          |        |        |         |
| 0                               | 10 630 | 4795     |          |        |        |         |
| 1                               | 2796   | 1612     | 1.19     | 1.10 to 1.28 | <0.01 |
| 2                               | 2204   | 1519     | 1.32     | 1.22 to 1.44 | <0.01 |
| 3                               | 1154   | 183      | 2.29     | 1.80 to 2.91 | <0.01 |

Table 2. Logistic regression model showing the predictors of SABA overprescribing (≥ 6 SABA in the previous 12 months) for adults with asthma

*This model is adjusted by Index of Multiple Deprivation score. ** This model is a mixed-effect multivariate logistic regression, which includes clustering based on the practice (Newham, Tower Hamlet and Waltham Forest). The adjusted interclass correlation coefficient of this variable is 0.006, which is negligible. CI = confidence interval. OR = odds ratio. SABA = short-acting beta-agonist.
current study it was possible to categorise ICS use for each patient for the previous 12 months as: MPR underprescribing (<50%); MPR expected use (50% to 120%); and MPR overprescribing (>120%) (see Table 3, Supplementary Information S1; and Supplementary Table S1 for further details). MPR use across the range of SABA prescribing in the previous year was examined. Figure 2 shows the fall in higher-than-expected ICS use (labelled ‘MPR overprescribing’) in parallel with the fall in number of SABA inhalers issued. It also shows that among patients prescribed between 6 and 11 SABA inhalers/year (likely a population with less controlled asthma) over a quarter of patients were issued fewer ICS prescriptions than expected (‘MPR underprescribing’). More than 80% (18 170/22 713), were underprescribed ICSs in the group of patients with SABA prescriptions <6 a year (likely a population with milder, better controlled asthma). Patients prescribed between 6 and 11 SABA inhalers a year and underprescribed MPR are a target group to focus on to reduce SABA overprescribing. Some may have significant asthma but inadequate preventive treatment that if improved will reduce their SABA prescriptions, others may need a review of their asthma diagnosis.

To calculate how many hospital admissions could be avoided by improving asthma management and hence reducing SABA overprescribing, the results of a previous publication15 based in the same multi-ethnic, deprived urban population, were used. In the current study, the hospital admission rate for SABAs ≥12 was 7.5% a year. As an estimate, by enabling a reduction of SABA prescribing for this group to between 4 and 12 SABAs (associated with a hospital admission rate of 2.3% a year), there is potential to avoid up to 70% of hospital admissions in this group.

### DISCUSSION

#### Summary

Rates of SABA overprescribing remain high in this multi-ethnic, deprived urban population, with significant variation among practices. About one-fifth of practices achieved a SABA overprescribing rate of <20% (23/117).

By converting both SABAs and ICSs to standard units in this study it was possible to make more accurate comparisons across prescribed medications. Among adult patients prescribed between 6 and 12 SABA inhalers/year [representing a population with less controlled asthma] over a quarter of patients were issued less ICS prescriptions than expected. Working with these patients to improve regular preventer use should be an early target to reduce SABA overprescribing by improving their asthma control and reducing breakthrough asthma symptoms for which they may take reliever medication.24

Logistic regression analysis shows that alongside markers of asthma severity, multimorbidity and the type of prescription are important independent predictors of SABA overprescribing.

#### Strengths and limitations

The study results are based on patients with asthma from a population of almost one million GP-registered patients in East London using prescribing data for a full year before data extraction. Results from this study will be generalisable to other multi-ethnic inner urban populations in the UK. With >93% ethnicity recording, it was possible to explore the contribution of ethnicity and deprivation alongside other established risk factors for SABA prescribing.

The asthma population in this study is based on diagnostic codes and asthma medication prescribed in the previous year, however, asthma overdiagnosis is known to occur in primary care26 hence some patients may have alternative diagnoses. The study measures prescriptions issued rather than medication taken. Receiving a prescription does not necessarily mean that the prescription was filled and used, and it is possible that ‘stock piling’ inhalers may inflate estimates of SABA overprescribing. It will also contribute to medication waste. The MPR calculations, comparing prescribed medication against standard expected use, are based on typical regimens for specific inhalers (see Supplementary Table S1), not the actual prescribed dosing frequency for individuals.

#### Comparison with existing literature

The results of the current study show that rates of SABA overprescribing are consistent

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### Table 3. ICS categorisation based on MPR percentage

| Description           | MPR % |
|-----------------------|-------|
| Overprescribing       | >120  |
| Expected prescribing  | ≥50 to 120 |
| Underprescribing      | <50   |

See Supplementary Information S1 for methods. ICS = inhaled corticosteroid. MPR = medication prescription refill.
with those reported in a recent Swedish study with patients aged 12–45 years and a German study of >12-year-olds, which found that about a third of patients with asthma are prescribed >3 SABAs/year. In common with the current study they developed a standard measure for ICSs (low, medium, and high dose), using budesonide equivalent doses. Consistent with the current findings, the proportion of patients with SABA overprescribing was higher in patients at GINA steps 3–5 compared with those at GINA step 1 or 2, a sign of poor asthma control in patients with severe asthma. This poor control was observed despite patients receiving ICSs/LABA. Indeed, at GINA steps 3–5, the risk of SABA overprescribing was highest in patients using ICSs/LABA. A recent multinational qualitative study aimed at identifying drivers of patients’ reliance on SABAs in asthma revealed that patients can have a strong emotional attachment to SABA relievers, driven by their efficacy and success in quickly alleviating symptoms. Moreover, some patients typically do not understand that the frequent use of SABAs indicates poor asthma control, whereas others have a misperception of ICSs, which could lead to a delay in escalation and poor adherence. Experiencing severe exacerbations can improve adherence to ICSs, but only temporarily in many cases. Further, some adolescents and young adults who are high users of SABAs adapt poorly to having asthma and have poor asthma control: overprescribing of SABAs is a convenient way to enable them to live their lives.

**Implications for practice**

The wide variation in SABA overprescribing rates between practices in the same localities suggest there is potential to reduce overprescribing rates in higher-prescribing practices. Sharing data on comparative prescribing rates between practices encourages reflection and the development of shared strategies for the reduction of overprescribing.

Providing practices with software tools to identify patients with asthma at high risk of hospital admission based on prescribing records is warranted. Such tools should be integrated with the software used by primary care teams, and enable the automatic flagging of patients overprescribed SABAs. Engaging practice teams to deliver systematic, structured asthma reviews is key to the optimisation of asthma management and prescribing.

Tackling SABA overreliance aligns with both the drive to improve asthma control and the drive to reduce the environmental impact of asthma care. This context offers an opportunity to significantly reduce the carbon footprint of the NHS.

The current study results highlight the importance of general practice teams working effectively with pharmacists to ensure a shared understanding on access to SABA medications. In some cases this may require removing SABA medications from repeat dispensing.

Improving asthma management, by adequate preventer treatment, education, and regular support can translate into a reduction in acute hospital admissions. If all practices were enabled to support patients prescribed >12 SABAs a year to reduce to 4–12 a year there is potential to reduce up to 70% of asthma admissions a year for this group.

**Funding**

The project was funded by Barts Charity reference MGU0419. REAL- Health: REsearch Actionable Learning Health Systems Asthma programme.

**Ethical Approval**

Ethical approval was not required for this study as patient-level data are anonymised, and only aggregated patient data are reported in this study. All GPs in the participating East London practices consented to the use of their anonymised patient data for research and development for patient benefit.

**Data**

All data relevant to the study are included in the article.

**Provenance**

Freely submitted; externally peer reviewed.

**Competing interests**

The authors have declared no competing interests.

**Acknowledgements**

The authors are grateful to the participating GPs for their cooperation without which such studies would be impossible. The authors wish to thank staff at the Clinical Effectiveness Group (CEG) for supporting practices with guidance and data-entry tools that support this project.

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