The National Health and Nutrition Examination Survey (NHANES), 2021–2022: Adapting Data Collection in a COVID-19 Environment

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See also Lau et al., p. 2085.

The National Health and Nutrition Examination Survey (NHANES) is a unique source of national data on the health and nutritional status of the US population, collecting data through interviews, standard exams, and biospecimen collection.

Because of the COVID-19 pandemic, NHANES data collection was suspended, with more than a year gap in data collection. NHANES resumed operations in 2021 with the NHANES 2021–2022 survey, which will monitor the health and nutritional status of the nation while adding to the knowledge of COVID-19 in the US population.

This article describes the reshaping of the NHANES program and, specifically, the planning of NHANES 2021–2022 for data collection during the COVID-19 pandemic. Details are provided on how NHANES transformed its participant recruitment and data collection plans at home and at the mobile examination center to safely collect data in a COVID-19 environment. The potential implications for data users are also discussed. (*Am J Public Health*. 2021;111(12):2149–2156. https://doi.org/10.2105/AJPH.2021.306517)

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The National Health and Nutrition Examination Survey (NHANES), conducted by the Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics (NCHS), has been monitoring the nation's nutrition and health for more than 5 decades. It collects data that can best or only be obtained by direct physical examination, clinical and laboratory tests, personal interviews, and related measurement procedures. The examinations are conducted in mobile examination centers (MECs) that travel to various locations throughout the country, providing a standardized environment for the health examinations. The information collected also includes data that cannot easily be reported by sample persons themselves or by their health care providers. NHANES data are used to estimate the prevalence of diagnosed and undiagnosed disease, including acute and chronic conditions, nutritional intake and status, chemical exposures, and much more.[1]

Since 1999, NHANES has been collecting data every year without disruption. However, in early 2020 with the emergence of SARS-CoV-2 (the virus that causes COVID-19), there was much uncertainty about virus transmission, infection, morbidity and mortality, and mitigation and prevention measures. Its impact on NHANES overall, and specifically on staff and participants, was unknown. NHANES is a complex data collection operation.[2] Field staff travel full-time to survey locations throughout the country, where COVID-19 exposure risk varied widely. Also, survey respondents, amid general public health warnings and guidance, were expected to be increasingly reluctant to open their doors for interviews or come to an MEC for fear of COVID-19 exposure. As a result, in March 2020, NHANES data collection efforts were stopped because of safety-related concerns.

As of June 2021, NHANES data collection had been suspended for 15

months. This disruption has led to a gap in the availability of recent NHANES data to inform public health research, programs, and policies. During this time, extensive efforts were made by NCHS staff to evaluate the data collected on an incomplete 2019–2020 survey sample, examine nonresponse bias, adjust sample weights, and create a combined 2017–March 2020 prepandemic analytic data set for researchers. The first set of data files were publicly released in May 2021, along with an Analytic Guidance and Brief Overview report that describes the creation of the data file and provides guidance for its analytic use.[3] A subsequent report further details the 2017–March 2020 prepandemic data file and provides key health estimates.[4]

Significant efforts were also made to return to data collection in 2021, considering prevalent COVID risk assessment. Assessing the level of risk remains complicated given the varying levels of risk across states, counties, and communities in the United States. Multiple vaccines also became authorized for use, beginning with the end of 2020.[5] However, conditions throughout the country still vary in terms of risk, incident case numbers, and morbidity and mortality rates. Given that the course of the pandemic in 2021 is unknown and the infection rates are anticipated not to be zero, several changes to the survey were necessary. The principles that guided these changes included the following:

1. ensure safety of survey participants and field staff,
2. reduce contact time with participants in the home and the MEC,
3. reduce respondent burden to maximize response rates,
4. maintain essential data collection to continue to monitor the nation's health, and
5. add COVID-19 content to further the understanding of the epidemiology of the disease based on a national sample.

This article describes the reshaping of the NHANES program and, specifically, the planning of NHANES 2021–2022 for data collection during the COVID-19 pandemic. The implications for data users are also discussed.

CHANGES TO THE SAMPLE DESIGN

Starting in 2023, NHANES is expected to undergo a substantial survey redesign.[6] Therefore, NHANES 2021–2022 will be the last cycle of a continuous survey that began in 1999 collecting data annually and publicly releasing data every 2 years. Over its history, NHANES has oversampled certain subgroups to ensure adequate sample sizes to obtain precise estimates for these groups. However, a 2-year sample has limited analytic utility to provide estimates for subgroups with lower percentage population distribution (e.g., non-Hispanic Asian persons). Often, a 2-year sample needs to be combined with adjacent 2-year samples to increase sample sizes to create a single estimate from the combined data set.[7] However, it may not be appropriate to combine the 2021–2022 data with the 2017–March 2020 data files, given that the 2017–2020 data were collected before the COVID-19 pandemic and there will be more than a 1-year gap between data collections.[3] NHANES 2023 will also be a new, redesigned survey. Therefore, NHANES 2021–2022 will, in effect, be a 2-year stand-alone survey. However, this does not preclude comparison of estimates from 2021 to 2022 with estimates from earlier survey cycles, depending on the research question and data available.

Operating in a COVID-19 environment also required the oversampling strategies to be reexamined. One consideration is the number of dwelling unit (DU) contacts required to complete eligibility screening. Oversampling increases this number, as the likelihood that any DU includes an eligible person decreases with oversampling and more DUs must be screened. Reducing the number of contacts is an important safety measure.

Given these factors, for NHANES 2021–2022, it was decided that the selection probability will only depend on age, regardless of gender, race, Hispanic origin, and household income level. The new 2021–2022 sampling strategy will decrease the number of households screened (from ~13 000 to ~7000), leading to fewer in-person encounters for field staff. Specifically, in a sampled DU, all children aged 19 years and younger and all persons aged 60 years and older will be eligible to participate. For persons aged 20 to 59 years, 1 or 2 persons will be eligible, depending on the total number of persons in the household aged 20 to 59 years. The reduction in the number of households screened does not change the targeted total examined sample of ~10 000 persons across the 30 primary sampling units (PSUs).

With no oversampling by race/ethnicity and income, there will be fewer sampling domains compared with earlier designs.[8] This will result in national estimates with increased precision, smaller expected variances, and lower design effects than estimates from the previous design. This will also provide

effective sample sizes necessary for key NHANES health outcomes that can be estimated with a 2-year sample. Further detail on assessing precision and statistical reliability of an estimate have been published elsewhere.[7]

As mentioned previously, the target number of examined persons will remain 10 000 across the 2-year period. The sample will be obtained from 30 PSUs that were selected out of over 3000 US counties. The first 15 PSUs and the later 15 PSUs will each be nationally representative. Table 1 provides a comparison of selected sample design parameters from the 2021–2022 and 2015–2018 survey samples.

As of June 2021, the dress rehearsal for the 2021–2022 survey has begun. Data collection at the first true PSU is targeted to begin soon afterward. To complete data collection in all 30 PSUs, the survey operations for this cycle will extend into 2023. Given the uncertainties of the COVID-19 pandemic, it is possible that start dates for specific PSUs may need to be shifted. If there are substantial delays with several PSUs due to such prevailing situations, NHANES may shift focus to complete only the first 15 PSUs in 2021–2022 to obtain 1 year of data collection targeting at least 5000 examined persons.

DATA COLLECTION

Prior to starting data collection in any NHANES location, to ensure the safety of all field staff and participants, COVID risk levels are closely monitored and field staff, who will be following all CDC recommendations, are encouraged to obtain available COVID-19 vaccines. Various data sets are used to compute metrics and risk-level measures similar to those developed by the Harvard Global Health Institute in their COVID Risk Level map and COVID suppression guidance.[9] In particular, NHANES uses the average of new daily cases of COVID-19 per 100 000 people over the last 7 days to classify counties in green (< 1 case), yellow (1–9 cases), orange (10–24 cases), and red (> 24 cases) risk levels. In-person data collection will only occur after assessment of a county's risk level and vaccination rates, field staff vaccination rates, and the latest CDC guidance. Given that this is an evolving pandemic with new guidance emerging periodically, we do not include here the specific terms for decision-making.

Identifying Eligible Persons

Historically, NHANES household interviewers attempt to make in-person contact at all selected DUs within each survey location. In the current COVID-19 pandemic environment, this face-to-face contact creates a potential risk of exposure for both the household interviewer and the household member. These risks are further amplified for DUs that are not single-family homes or do not have exterior-facing entrances (condominiums, apartments, dormitories, etc.).

For NHANES 2021–2022, eligibility screening will be carried out using a multimode approach. Sampled DUs will be mailed an invitation letter asking them to complete a short survey online

TABLE 1— Selected Sample Design Parameters: United States, National Health and Nutrition Examination Survey, 2015–2018 and 2021–2022

Characteristic	2015–2018[8]	2021–2022
Age of noninstitutionalized civilian target population	All ages	All ages
Geographic area	United States[a]	United States[a]
Sample design	4-y, stratified, clustered 4-stage samples	2-y, stratified, clustered 4-stage samples
Number of study locations	60	30
Domains for oversampling	Predesignated: 87 domains of gender–age groups for non-Hispanic Black persons; non-Hispanic, non-Black Asian persons; and Hispanic persons, and income–gender–age groups for other persons	Predesignated: 3 domains of age groups (0-19, 20-59, ≥ 60 y)
	Oversampled: Hispanic persons; non-Hispanic Black persons; non-Hispanic, non-Black Asian persons; low-income White and other persons (at or below 185% of federal poverty level); children aged 0–11 y; and adults aged ≥ 80 y	Oversampled: younger (0–19 y) and older (≥ 60 y) age groups
Number of examined persons	18 248	10 000 (targeted)

[a]Includes 50 states and the District of Columbia. US territories are not included in the National Health and Nutrition Examination Survey sample.

or via a toll-free number. Nonrespondents will receive a series of follow-up reminders, including a postcard, a paper copy of the eligibility screener, and a final reminder letter. Households that choose not to self-respond will receive an in-person visit by a household interviewer.

Household interviewers will contact all identified eligible household members to further explain the survey, gain their cooperation, and schedule personal interviews. Contact approaches will vary by the information provided by each household in their screener questionnaire (e.g., telephone number).

Changes to Household Interviewing

For eligible persons, NHANES conducts personal interviews followed by physical examinations and laboratory testing. Since 1999, the household interview has been conducted by trained interviewers in the participant's home using a computer-assisted personal interview system where demographic, socioeconomic, dietary, and health-related information has been collected.[10] For NHANES 2021–2022, those eligible and agreeing to participate will schedule a telephone appointment to complete the home interview. However, it may be conducted in the home if preferred, and all current CDC safety guidelines are followed.

Participation in the NHANES survey is voluntary, and prior to the start of the household interview, participants (sample persons, or SPs) are asked to provide verbal consent to participate. They are also sent, via postal mail or delivery by hand, a packet of materials that include a paper copy of the consent brochure, which will be reviewed with the household interviewer as part of scheduling the MEC appointment.

As in previous years, the interview will consist of the SP Questionnaire, which collects individual health-related data, and the Family Questionnaire, used to collect information at the household level (e.g., total family combined income and housing characteristics).[11] However, to decrease respondent burden on the phone and to increase interview completion, significant reductions to both the SP and Family Questionnaires were made to reduce the total phone interview time to under 60 minutes. Decisions on specific questions were made only after decisions were made on exam content to align all content. The SP Questionnaire was cut by over 50% and the Family Questionnaire by about a quarter. Based on 2019–2020 completion times for in-person interviewing, the expected median times for the 2021–2022 SP Questionnaire will range from between 10 and 25 minutes, depending on a person's age, and median administration time for the Family Questionnaire will be approximately 10 minutes. However, it is expected that the phone interviewing will add additional time to the estimated times, given the need for more explanations in lieu of using hands cards that were shown to participants with the additional information.

Given the change in mode of administration as well as the uncertainties of collecting data in a COVID-19 environment, it is not clear what level of response may be expected in 2021–2022. To increase participation in the SP interview, NHANES has introduced a $25 participant incentive. Historically, incentives have only been provided for MEC participation. However, the overall incentive totals have not been modified (ranging from $130 to $175 based on participant's age plus additional transportation and other allowance, if applicable). For the 2021–2022 survey, the timing of receipt of incentives has been shifted to better align with participant burden.

In addition to dropping some SP and Family questions, certain in-home data collections will be discontinued since the interview will now be conducted via phone. These include home water sample collection to test for fluoride, home dietary salt collection to test for iodine, and infant formula ingredients collection. In addition, information on dietary supplement use during the past 30 days, which was traditionally collected at the home interview, will be collected after the Day 1, 24-hour dietary recall over the telephone. Table 2 provides a summary of the changes to the household interviewing component.

Because of the COVID-19 pandemic and the anticipated survey redesign for 2023 onward, no new content was solicitated for the 2021–2022 survey cycle. Survey content in 2021–2022 is significantly condensed and modified to adapt to the pandemic–postpandemic environment. Stakeholders and collaborating agencies were consulted in the planning activities of the 2021–2022 survey content. Public solicitation on new content is planned to be resumed for NHANES 2023 and beyond.

Health Examinations at the Mobile Examination Center

To return NHANES to data collection in a COVID-19 environment, critical decisions had to be made about what exam content could be conducted in 2021–2022. These decisions were first guided by the safety of staff and participants, and whether any change could

TABLE 2— National Health and Nutrition Examination Survey 2021–2022 Household Interview Content: United States

Modified	Added	Cycled Out
All Sample Person questions conducted via phone or in-person	COVID-19	Over 50% of Sample Person questions
All Family questions conducted via phone or in-person		~23% of Family questions
Dietary supplement use (past 30 days) moved to post exam interview with Day 1 24-h dietary phone interview		Home dietary salt collection to test for iodine
		Home water sample collection to test for fluoride
		Human papillomavirus (HPV) oral rinse
		Infant formula ingredients collection

Note. Refer to NHANES Web site for 2019–2020 Sample Person and Family Questionnaire Instruments.[11]

reduce the amount of time a participant and health examiner would spend in close contact in the MEC. Another consideration was which measures could be collected during a 2-year survey, to yield statistically reliable estimates overall and for certain subgroups. Additional attention was given to whether data on certain topics (e.g., hearing, oral health) that were collected in previous cycles were needed in the 2021–2022 data collection and whether a potential gap in available data was acceptable, or if continued data collection in 2021–2022 on those variables was truly necessary from a public health perspective. However, data that contribute to key national health outcomes that only come from NHANES examination data (e.g., anthropometry for obesity, blood pressure for undiagnosed hypertension, fasting plasma glucose for undiagnosed diabetes) would continue to be collected. Lastly, data collected on new content during 2019–2020 were also considered for dropping, since they no longer could be combined across the 4-year period from 2019 to 2022. Table 3 provides the specific MEC content for the 2021–2022 survey cycle that was unchanged, modified, added, or cycled out.

Similar to the mode changes of the SP and Family questionnaires, the mode of some of the MEC data collection also had to change. Specifically, the Day 1 Dietary Interview, which was historically administered in person at the MEC,[10] will now be conducted by telephone (as has been the case for the Day 2 Dietary Interview since continuous NHANES began; see section on Dietary Assessment for more detail[10]). Additionally, to further reduce contact between SPs and staff, most MEC interview questions will be self-administered by participants using the audio-computer-assisted self-interview (ACASI) system using a touch screen computer. Table 4 summarizes the overall mode changes.

Mobile Examination Center Modifications

As stated previously, NHANES examinations are conducted in MECs that travel to 15 survey locations annually. Each MEC is made up of 4 interconnected semitrailers.[2] Because of COVID-19 concerns, these trailers were all

TABLE 3— National Health and Nutrition Examination Survey 2021–2022 Mobile Examination Center (MEC) Examination Content: United States

Unchanged	Modified	Added	Cycled Out
Body measures	Balance—Modified Romberg Test	COVID-19 Screening Questionnaire and Serology	Audiometry
Blood pressure	Day 1 Dietary Interview via phone		Cognitive functioning
Dual-energy x-ray absorptiometry (DEXA)—whole body	MEC Interview via ACASI		DEXA—spine and femur
Liver elastography			Oral health
Phlebotomy			Words-in-noise

Note. ACASI = audio-computer-assisted self-interview. Refer to NHANES Procedure Manuals for 2017–2018[12] and 2019–2020[10] for further details on each content area.

TABLE 4— Mode of Data Collection Components: United States, National Health and Nutrition Examination Surveys, 2019–2020 and 2021–2022

Order	Component	2019–2020	2021–2022
1	Household Screener and Relationship Questionnaire	In-person	Multimode
2	Sample Person and Family Questionnaires	In-person	Telephone
3	Mobile Examination Center (MEC) Exam: Interview portion	In-person, some ACASI	Primarily ACASI
4	Day 1 Dietary Interview	In-person (at MEC)	Telephone (post MEC)
5	Day 2 Dietary Interview	Telephone (post MEC)	Telephone (post MEC)
6	Food Consumer Behavior Survey	Telephone (post MEC)	Telephone (post MEC)

ACASI = audio-computer-assisted self-interview.

refurbished. Several rooms were enlarged, and additional waiting rooms were created to allow for greater social distancing between participants and staff. Each trailer has 1 or more independent HVAC systems. In addition to implementing practices recommended by the CDC, NHANES replaced several HVAC units with systems that use Minimum Efficiency Reporting Values—13 filters, which have been shown to remove viruses from circulated air. A needlepoint bipolar ionization system was installed in all remaining trailers. This duct-mounted system has been shown to enhance the efficiency of existing HVAC filters. These changes will enhance the MEC ventilation systems to maintain optimal air circulation and quality.

A limited number of staff and participants will be allowed on the MECs at any one time to maintain as much social distancing as possible. All staff will be encouraged to be vaccinated. Personal protective equipment will be worn by all staff, who will maintain strict disinfection and risk-mitigating strategies following CDC guidelines. Staff will be required to conduct daily self-assessments of symptoms prior to work. Unvaccinated staff will receive COVID-19 polymerase chain reaction (PCR) testing on a weekly basis. Any staff who test positive or are determined to be in close contact with a positive individual will remain in isolation until cleared based on CDC guidance or by their medical provider. NHANES will take all necessary actions to inform participants and other NHANES staff of possible exposure.

Prior to participant entry to the MEC for a scheduled exam, NHANES staff will conduct body temperature checks and ask COVID-19 screening questions to all participants.[13] Body temperature at or above 100.4°F or affirmative responses to specific questions will necessitate cancellation and rescheduling of the appointment. Lastly, all participants will also be required to wear masks.

Dietary Assessment

Data on dietary intake and dietary supplement use as well as food consumer behavior will be collected following the MEC visit and will be conducted over the telephone.

The dietary intake component of NHANES, called What We Eat in America, is conducted as a partnership between the US Department of Agriculture (USDA) and the US Department of Health and Human Services. Under this partnership, NHANES uses the USDA's Automated Multiple Pass Method (AMPM) to collect 24-hour dietary recalls by trained dietary interviewers.[14] Since 2002, NHANES has successfully collected an in-person Dietary Interview in the MEC (Day 1) followed by a second interview over the telephone (Day 2) using the AMPM as described previously.[15]

As noted previously, in 2021–2022, the mode of the Day 1 Dietary Interview will be changed to telephone to limit face-to-face contact with respondents. The Day 2 Dietary Interview will remain unchanged (by phone). The methodology of dietary data collection will otherwise remain the same as described previously.[15]

The Dietary Supplement Questionnaire to collect information on 30-day supplement use, which used to be collected as part of the SP Questionnaire at home, will be administered after the Day 1 Dietary Interview over the phone. The 24-hour dietary supplement use data collected during 24-hour recall (Day 1 and Day 2) will not be included during 2021–2022. As collected in earlier NHANES cycles, the Flexible Consumer Behavior Survey Phone Follow-Up Questionnaire will be administered over the phone after the second dietary interview is completed.

COVID-19–Specific Content

NHANES is unique in that it collects data through interviews, in-person

examination, and biospecimen collection. This offers a great opportunity to add COVID-19–specific content to obtain a more comprehensive understanding of the epidemiology of COVID-19 in the United States. There are 2 main COVID-related areas of content in 2021–2022 (Appendix, available as a supplement to the online version of this article at http://www.ajph.org). First, as part of the SP Questionnaire, questions were added on previous infection status and severity of symptoms, infection and antigens testing, vaccination, COVID-related hospitalizations, history of weakened immune system, and whether any household member ever tested positive for COVID-19. These questions are asked again at examination. Second, participants who receive phlebotomy at the MEC will have their blood samples tested for the SARS-CoV-2 nucleocapsid protein as well as the spike protein. Antibodies to the nucleocapsid protein indicate only natural infection regardless of vaccination status, whereas antibodies to the spike protein indicate either natural infection or vaccination.[16] Thus, a key contribution of NHANES 2021–2022 will be that the data collected from both of these antibody tests could provide nationally representative prevalence data on both natural COVID-19 infection and vaccine-induced immunity to the virus.

The science and knowledge of the disease, the virus, and immunity continue to develop. Therefore, NHANES will need to quickly adapt and add or modify the COVID-19 content, as needed.

DATA RELEASE AND ANALYSIS

The goal of NHANES 2021–2022 is to collect and publicly release a 2-year sample with data from 30 PSUs on about 10 000 examined persons. If successful, these data, like other NHANES 2-year data, would be made available on the NHANES Web site. Survey sample weights would be provided to account for any survey nonresponse. Data users should use the sample weights to account for the complex survey design in the estimation of variance.

Because of the COVID-19 pandemic, data collection may only occur in about 15 PSUs with a reduced examined sample size. Although the sample will be nationally representative, with such a small number of PSUs, estimates for the single year of data may be relatively unstable (i.e., have large variance estimates). Releasing only 1 year of data increases the possibility of disclosure of a participant's identity and, as a result, the single year of data would not be released publicly because of confidentiality or disclosure risk and instead would only be accessible via the NCHS Research Data Center.[17]

The expected sample sizes of screened and examined persons have been computed on the basis of past NHANES experience with response rates,[18] but these were prior to COVID-19. The overall examination response rate for NHANES 2021–2022 is hard to predict during the COVID-19 pandemic environment. It is especially hard to know how these response rates will be affected by general population concerns because of COVID-19, or the changes to the sample design, operations, and MEC procedures. Nonresponse bias will be examined as data are collected, as well as after all data collection has been completed prior to data release.

Prior to analyzing data, regardless of whether it is a 2-year 2021–2022 sample or only a 1-year sample, data users will need to review all data documentation and understand changes to the questions and exams from prior cycles. Data users should read the NHANES Analytic Guidelines and relevant documentation on the survey overall and specific data files to be used in their analysis. They will also need to determine the adequate sample sizes needed to obtain statistically reliable estimates for the health outcomes of interest for the population and for specific subgroups. Note that the change in sample design, where there will be no oversampling by race and Hispanic origin and income, will affect sample sizes for specific subgroups. Additionally, any comparisons made between the 2021–2022 cycle and earlier NHANES cycles need to consider the impact of COVID-19 during the data collection period as well as the changes described in this article to the survey overall (e.g., data collection mode differences). Analytic details will be provided in data documentation and publications that accompany the data release.

CONCLUSIONS

Over many decades, NHANES has been a unique source of national data on the health and nutritional status of the US population through standard exams and biospecimen collection. After more than a 1-year gap in data collection, in June 2021 NHANES began the dress rehearsal for the 2021–2022 survey cycle and plans to resume full operations soon thereafter. NHANES has transformed its participant recruitment and data collection plans to collect data in a COVID-19 environment as safely as possible. Data collection for the 2021–2022 sample is expected to occur through 2023, with data release

beginning in mid-to-late 2023. NHANES's success will be determined by each person who participates in the survey, as well as all the NHANES partners who continue to see the survey's value and provide support through funding, staffing, and other means. NHANES 2021–2022 will continue to monitor the health and nutritional status of the nation while adding to the knowledge of COVID-19 in the US population. AJPH

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CONTRIBUTORS

R. Paulose-Ram and N. Ahluwalia conceptualized the study and drafted the article. J. E. Graber and D. Woodwell provided significant input, review, and editing. All authors read and approved the final article.

CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

HUMAN PARTICIPANT PROTECTION

Centers for Disease Control and Prevention research on human participants complies with the Health and Human Services Policy for Protection of Human Research Subjects. All National Health and Nutrition Examination Survey procedures and protocols have been reviewed and approved by the National Center for Health Statistics Research Ethics Review Board.

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